

Table 32
Subsidence Monitoring Requirements Comparison

	EIS Table 1-5	ROD	Jacobs Environmental Monitoring Plan	Actual
Sampling Points	89	Item 10: Per EIS Table 1-5	Whichever of 89 remain usable and reliable. Stations must be surveyed to 0.05 inch.	No Monitoring Done
Frequency	Quarterly		Quarterly during time periods when New NM 279 is closed. Monthly at sites that indicate 0.5 inch in any Quarter or 1.0 inch in a year. Visual survey conducted quarterly by walking both side of Old NM 279 and document in letter to POL and BIA any obvious signs of subsidence.	
Parameters	Ground Movement		Elevation Change	
Duration	Until SH279 is Re-aligned		During Periods of longer than 30 days when New NM 279 is closed and Old NM 279 is in use.	

Conclusions - The new highway was never closed for extended periods and the public is *not required* to use Old NM 279, so the letter of the ROD was met even though no monitoring took place.

Recommendations – Periodic inspection of Old NM 279 is recommended for subsidence and erosion.

➤ **Ground Vibration**

The Jacobs Environmental Monitoring Plan states that blasting to reduce highwall slopes will be in “OPTIONAL” work package items which would be dependent on funding and POL desires.

**Table 33
Blast Monitoring Requirements Comparison**

EIS Table 1-5		ROD	Jacobs Environmental Monitoring Plan	Actual
Sampling Points	Variable	Item 10: Per EIS Table 1-5	1.) Three locations in Village 2.) One location east perimeter of Village	Project Status Report No. 9, April 1990 references a Seismic Study.
Frequency	Each Blast		Each Blast - After USGS Case Study	Project Status Report No. 11, June 1990 references a Blast Study of Buildings in the Village.
Parameters	Particle and air blast		1.) Ground Acceleration (Measured) and Ground Particle Velocity (Calculated) 2.) Air Blast	
Duration	Until all blast is completed		During Blasting	

Conclusions - The blasting in the South Paguate Pit was carefully monitored and formal reports were issued. There was a damage assessment performed in the Village of Paguate where considerable damage was documented. This was followed by inspections of other pit highwalls revealing considerable integrity of highwalls and few expected safety issues related to letting the areas erode naturally. The decision by POL and BIA was to forego further blasting of highwalls, but to visually inspect the highwalls for safety issues.

Recommendations - A field assessment of the highwalls should be made to determine the hazard potential, if the walls are eroding safely or if not then if additional fencing or other corrective measures are required during the erosion process. If significant hazard potential is present, other means of slope reduction should be evaluated, such as ripping, or alternatively, localized berming or other protective measures may be warranted.

11. SECURITY

Control of minesite access and security will continue during reclamation and monitoring activities. However, security during the monitoring phase will require cooperation from Pueblo of Laguna and BIA to prevent livestock grazing on revegetated sites.

This ROD item has no specific requirements to be met. Project Status Reports and observations in August 2006 indicate that grazing has not been prevented. While the data indicates that the plant uptake of radionuclides and heavy metals are no threat to

humans or wildlife, the groundwater concentrations for some contaminants of concern are elevated and further study is needed to determine the risk.

Conclusions - These requirements are addressed previously in the report. Additional sampling is required especially in the open pits and ponded water. Risk assessment may be required before grazing and other uses are allowed.

Recommendations - Immediate re-sampling of the pit water and ponded water is recommended. Evaluation of the radiological data is recommended.

12. RECLAMATION COMPLETION

Reclamation will be considered complete when revegetated sites reach 90 percent of the density, frequency, foliar cover, basal cover, and production of undisturbed reference areas (but not sooner than 10 years following seeding). In addition, gamma radiation levels must be no greater than twice background over the entire minesite. Outdoor radon 222 concentrations must be no greater than 3 pCi/l. Radon daughter levels (working levels) in any remaining surface facilities must not exceed 0.03WL.

Conclusions - These requirements are addressed previously in the report. See previous discussions concerning revegetation, gamma radon, radon and radon daughter levels in Sections 9 and 10. Alternative methods used to survey vegetation indicate the revegetation was successful.

Recommendations - Please refer to previous recommendations concerning revegetation, gamma radon, radon and radon daughter levels in Sections 9 and 10.

13. POST-RECLAMATION LAND USES

Limited livestock grazing, light manufacturing, office space, mining and major equipment storage will be allowed. Specifically excluded are habitation and farming.

("Jackpile Reclamation Project, Final Design Recommendations for BIA Approval", May 9, 1990 (pg 2, ¶ 3).

"9) *Elimination of the need for long-term maintenance of the site should be re-examined. Since monitoring must continue in the areas of ground water, revegetation success, and other environmental concerns, periodic inspection/repair of any noticeable erosion problems could be left under Pueblo of Laguna "care-taker" status and funded from the ground water monitoring. Although "elimination of post-reclamation maintenance" is one of the goals, situations may arise requiring some remedial action which, if performed early enough, will help to achieve the desired long-term stability. Monitoring of the inevitable livestock grazing and insuring that no farming or*

home building takes place on the site is judged to require some proactive effort."

Conclusions – All *non-compliant* and *potentially non-compliant* issues need to be resolved before recommendations and discussions concerning long-term use can be undertaken.

Recommendations – This topic should be discussed with POL after all compliance issues have been resolved, recommended sampling and analysis completed, and risk assessment determinations have been made. Land use should be restricted, as it currently is, until all compliance issues are resolved.

V. CONCLUSION AND RECOMMENDATIONS

ROD Requirements	
1. PIT BOTTOMS	
A. Backfill Levels:	
1. Pits will remain as closed basins. Pit bottoms will be backfilled to at least 10 feet above the Dames and Moore (1983) projected ground water recovery levels as indicated below. A schematic diagram is shown in the FEIS:	
<u>Pit:</u>	<u>Proposed Minimum Backfill Level:</u>
Jackpile 41	5,939 ft. amsl
North Paguate 20	5,958 ft. amsl
South Paguate 34	5,995 ft. amsl
South Paguate 35	6,060 ft. amsl
Conclusions - All monitoring well installation indicate that the minimum finished grades were achieved.	
Recommendations - Based on the fact that backfill elevations in all cases met or exceed the minimum proposed backfill level(s), the ROD objective has been achieved.	
2. A groundwater recovery level monitoring program will be implemented. Additional backfill will be added as necessary to control ponded water. The duration of the monitoring program will be a minimum of 10 years.	
Conclusions - Based on the fact that there is little elevation data where ten years of data are required and only one sample of the ponded water, accordingly, this aspect of site reclamation is considered <i>non-compliant</i> with the requirements of the ROD.	
Recommendations -	
<ul style="list-style-type: none"> During preparation of this report, OAS made the recommendation that the two wells required by the ROD should be installed in the Jackpile Pit. This was done in April 2007 Water table elevations should be monitored over a number of years to determine if the levels have stabilized, or are increasing or declining in order to evaluate whether the 10-foot below surface requirement is being met. 	

<ul style="list-style-type: none"> • Ponded water, wherever found within the pits, should be collected for chemical analysis. <p>These data can then be used to assess the risk of ponded water. The data can then be analyzed to determine if the water is groundwater or surface water and whether the chemical constituents present a threat to wildlife, domestic stock, or humans. As wetland areas are diverse ecosystems that are widely valued, it may be prudent to leave the North Paguate area as a wetland if the risk analysis so justifies. If chemical analysis indicates an unacceptable risk, then the ROD requirement to add additional fill to low areas would be warranted.</p>
<p>B. <u>Backfill Materials:</u> Backfill materials will consist of protore, waste dumps H and J, and excess material obtained from waste dump resloping and stream channel clearing. These materials will be covered with 3 feet of overburden and 2 feet of topsoil (i.e. Tres Hermanos Sandstone or alluvial material).</p>
<p>Conclusions - Although, Dumps H and J were not moved, there appears to be substantial compliance to the ROD. There was sufficient backfill material in proximity to the pits that Dumps H and J volumes were, in fact, not needed. The cover, slopes, and vegetation on these waste piles appear to be stable.</p>
<p>Recommendations – No further activities are recommended at this time.</p>
<p>C. <u>Stabilization:</u> All backfill slopes will be reduced to no greater than 3:1 (horizontal to vertical). Surface water control berms will be constructed within pit bottoms to reduce erosion and retain soil moisture for plant growth. Surface runoff will also be directed to small retention basins in the pit bottoms. All areas in the pits will then undergo surface shaping, topsoil application, and seeding as outlined under “Revegetation Methods” below.</p>
<p>1. Sloping</p> <p>Conclusions - There appears to be <i>non-compliance</i> to the letter of the ROD requirements in regard to the sloping. But many deviations were approved. It is difficult to determine pile by pile what exactly was done according to the ROD 3:1 sloping requirement and/or in accordance with the approved changes. In the OAS site inspection, there were no observed problems with the slope grades. Although there are deviations to the ROD, they appear to have met the intent of the ROD.</p> <p>Some of the long runs of the terracing do appear to cause chronic blow-outs in some areas due to the pressure head of water building up along the terrace berm.</p>
<p>Recommendations - There are no corrective actions recommended</p>
<p>2. Pit Berms and Retention Ponds</p>
<p>Conclusions – The pit berms and retention ponds are not believed to be a concern for post closure health and environmental risks.</p>
<p>Recommendations - No further activities are recommended.</p>
<p>D. <u>Post-Reclamation Access:</u> Human and animal access to pit bottoms will be prevented with the use of sheep-proof fencing due to the uncertainties of predicting radionuclide and heavy metal uptake into plants (forage).</p>
<p>Conclusions - There appears to be substantial <i>non-compliance</i> with both the letter and</p>

intent of this ROD requirement. The fencing is clearly inadequate to prevent grazing. Installation of the perimeter fencing was approved in 1989. The perimeter fencing cannot be removed and should be maintained. At least one more sampling event of vegetation and surface water for both chemical constituents and radiological levels needs to be conducted in the North Paguate pit. Additional backfilling or permanent fence installation at North Paguate may be required based on those sampling events.

Recommendations – Additional monitoring and risk assessment is required to determine if there is any potential for impairment to the natural resources (both water and vegetation) that are needed for grazing domestic animals and wildlife. Pit bottoms need to be fenced until a recommended risk assessment is completed.

2. PIT HIGHWALLS

A. Jackpile Pit Highwall:

The top 15 feet of highwall will be cut to a 45-degree slope. All soil and unconsolidated material at the top of the highwall will be sloped 3:1. The highwall will be scaled to remove loose debris.

B. North Paguate Pit Highwall:

The top 15 feet of highwall will be cut to a 45-degree slope. All soil and unconsolidated material at the top of the highwall will be sloped 3:1. The highwall will be scaled to remove loose debris. Additionally, the highwall will be fenced with 6-foot chain link.

C. South Paguate Pit Highwall:

The top 15 feet of highwall will be cut to a 45-degree slope. All soil and unconsolidated material at the top of the highwall will be sloped 3:1. The highwall will be scaled to remove loose debris. Additionally, the highwall will be fenced with 6-foot chain link.

Conclusions - This aspect of site reclamation is considered compliant with the desires of the Pueblo of Laguna and the deviation from the ROD requirements is well substantiated with the results of the blast studies. The Jacobs Environmental Monitoring Plan listed this approach as an option that could be based on the wishes of the Pueblo of Laguna.

Recommendations - A field assessment of the highwalls and Old Highway 279 should be made periodically to make sure that the highwalls do not comprise a threat to normal Pueblo of Laguna activities, or if additional fencing or other corrective measures are required during the erosion process. If significant hazard potential is present, other means of slope reduction should be evaluated, such as ripping, or alternatively, localized berming or other protective measures may be warranted. The south-facing wall at the North Paguate pit also needs to be periodically assessed to assure that it is eroding sufficiently to cover the exposed Jackpile Sandstone, as planned.

3. WASTE DUMPS

- a. Waste dumps H and J will be relocated to Jackpile pit as backfill.
- b. Most dump slopes will be reduced to 3:1 or less and the dump slopes will be contour furrowed; exceptions are noted in Table I-4 of the FEIS.
- c. Dumps which have Jackpile Sandstone on their outer surface and any Jackpile Sandstone exposed during resloping will be covered with 3 feet of overburden and 18 inches of topsoil.

<p>d. Berms will be installed on all dump crests to control erosion. All dump tops will slope slightly away from their outer slopes. Dump slopes will be contoured so their toes are convex to prevent formation of major gullies on slopes.</p> <p>e. Additional surface treatment is outlined under "Revegetation Methods" below. Detailed modifications and treatments are presented in Table I-4 of the FEIS.</p>
<p>Conclusions - OAS considers the non-use of dumps H and J (as backfill) to be a non-substantive variance from the ROD requirements, given that the features were otherwise closed in accordance with specified procedures. Issuance of Construction Specifications with alternate cover requirements from the ROD, implies an acceptance of those new depths by the relevant parties. However, the berming design that was implemented for the reclamation did not perform as expected. The areas of chronic erosion blow-outs will be considered non-compliant if radioactive material is exposed or RAD levels exceed the specified limits.</p>
<p>Recommendations - An evaluation of the chronic blowout areas, to determine if solutions can be designed to relieve these continuing maintenance problems, is recommended. Erosion should be monitored with appropriate equipment to determine if radiological safety is a concern. If the underlying material is non-RAD emitting, the slopes may be allowed to erode naturally.</p>

<p>4. PROTORE STOCKPILES</p>
<p>All protore will be used as backfill material in pit areas. Backfill will be covered with 3 feet of overburden and 2 feet of Tres Hermanos Sandstone or alluvial material.</p>
<p>Conclusions - While the letter of the ROD was not met, the revised shale barrier depth was met in all cases tested. The top soil cover was less than the revised 24 inches, but in all cases it was at least 18 inches. The gamma concentration, after placement of the cover, was below the criteria of twice background levels.</p>
<p>Recommendations - Although the covers did not meet the ROD or the reclamation specifications, the covers appear to be adequate for radiation safety concerns. No further action is recommended.</p>

<p>5. SITE STABILITY AND DRAINAGE</p>
<p>A. Stream Stability:</p>
<p>1. All contaminated soils and fill material within 100 feet of the Rio Paguate west of its confluence with the Rio Moquino, will be excavated and relocated to the open pits.</p>
<p>Conclusions - The reclamation actions appear to have been compliant with this item of the ROD.</p>
<p>Recommendations - No further activities are recommended.</p>
<p>2. For the Rio Moquino, waste dumps S, T, U, N, and N2 will be pulled back 50 feet from the centerline of the stream channel. The toes of these dumps will be armored with rip-rap.</p>
<p>Conclusions - The material appears to have been relocated or pulled back and armored</p>

<p>to the specifications of the ROD and the approved changes. The Landmark/Weston Design, (Landmark Reclamation/Weston, "<i>Jackpile Reclamation Project, Pueblo of Laguna, New Mexico, Draft Special Case Designs</i>", December 1990) with the approved changes, reduced the rigor of the original erosion protection. The approved design was implemented and the letter of the ROD was met. However, the intent of the ROD is not being met because the design was inadequate to prevent erosion of the banks below the toes of the waste piles.</p> <p>However, significant erosion has taken place in the past 12 years. If erosion continues at the same rate, there is serious potential for exposure of waste or contaminated soil at the toes of Piles S, T, U, N, and N2. In view of the fact that a less rigorous redesign was approved after the ROD, this unexpected erosion is a problem. If the erosion continues, waste material will be exposed creating the potential risk of human and wildlife exposure to unknown hazards, and a threat to the water quality of the Rio Moquino.</p>
<p>Recommendations - A more thorough inspection and hydraulic analysis and erosion study needs to be performed to determine if additional erosion protection is needed along the Rio Moquino above the confluence. A control structure on the Rio Moquino above the Pueblo of Laguna section may also be considered.</p>
<p>3. A concrete drop structure will be constructed across the Rio Moquino approximately 400 feet above the confluence with the Rio Paguate.</p>
<p>Conclusions - Due to the flash flood event that caused the stream crossing to be relocated and changed the stream flow conditions, the Rio Moquino drop structure was no longer needed. Therefore, compliance with this ROD requirement is not applicable.</p>
<p>Recommendations - No further activities are recommended.</p>
<p>B. Arroyo Headcutting:</p>
<p>Arroyos south of waste dumps I, Y, and Y2, and the arroyo west of waste dumps FD-1 and FD-3 will be armored as shown in the FEIS Appendix A (Figure A-13). Other headcuts encountered during reclamation will also be stabilized by armoring.</p>
<p>Conclusions - Based on OAS field inspection documented in the photograph, field conditions changed when the headcutting encountered a natural outcropping of sandstone. The sandstone impedes further headcutting negating the need for armoring. Therefore, this is considered a non-substantive variance from the ROD requirements.</p>
<p>Recommendations - No further activities are recommended at this time.</p>
<p>C. Blocked Drainages:</p>
<p>1. Waste dump J and protore stockpiles SP-17BC and SP-6-B will be removed to unblock ephemeral drainage on the south side of the mine site.</p>
<p>Conclusions - While the letter of the ROD was not met with regard to the movement of waste dump J, closing it in place appears to meet the intent of the ROD and no problems have arisen to date by this action. However, this area could be a physical hazard in that livestock could become entangled in the submerged fence, or stuck in the mud.</p>
<p>Recommendations - Because the land grant property is in close proximity to the Pueblo of Laguna, an effort should be made to jointly maintain the existing dirt banks and monitor the ponded water to determine if it presents any chemical or radiological hazard for domestic animals or wildlife. After the evaluation has been completed, a long-term</p>

solution may be devised.
2. Two blocked drainages north of FD-I and F dumps will remain blocked. The remainder of the minesite, excluding open pits, will drain to Rios Paguate and Moquino.
Conclusions - The letter of the ROD has been met. However, an unforeseen circumstance has arisen in that the ponded water appears to be at least a physical hazard, and potentially a chemical and radiation hazard, for the neighboring landowners and the cattle that are grazed on that land.
Recommendations - Since grazing livestock have access to the ponded water, POL should sample the water to determine if it presents any chemical or radiological threat to the grazing animals. Additionally, the pond has been in the past, a physical hazard for the domestic animals. The area needs to be evaluated and a long-term solution devised.

6. SURFACE FACILITIES/STRUCTURES
A. Lease No. 1: All buildings on Lease No. 1 (Jackpile lease) will be demolished and removed except for the Geology building, miner training center and buildings at the old shop and the open pit offices. The land surface (except pit highwalls and natural outcrops) will be cleared of radiological material (e.g., Jackpile Sandstone) until gamma readings of twice background, or less, are achieved. These areas will then be graded and seeded.
B. Lease No. 4: All structures and facilities associated with the P-10 mine and new shop, including all buildings, roads, parking lots, sewage systems, power lines and poles, will be left in place. All operational and maintenance equipment, including tools, machinery, and supplies will be removed. All permanent structures and land surfaces (except pit highwalls and natural outcrops) will be cleared of radiological material until gamma readings of twice background or less are achieved. These areas will then be graded and seeded. Non-salvageable contaminated buildings and materials will be removed to the pits for disposal.
C. Access Routes: The four major roads within the mine site will be cleared of radiological material and left after reclamation for post mining use. These access routes include: 1) the access road from P-10 and the new shop area to State Highway 279; 2) the main road through the mine; 3) the road that passes between the housing area and North Oak Canyon Mesa and then proceeds to P-10; and, 4) road to Jackpile well No. 4. All other roads (except on lease No. 4) will be removed. These areas will then be graded and seeded.
D. Water Wells: Jackpile well No. 4, the P-10 well, the new shop well, the old shop well, and the 3 wells with associated sheltering structures (near the housing area) will be left. The pumps, riser pipe, wiring, and water storage tanks will be removed. Wells established for future monitoring purposes will also be left. All wells will be capped to prevent dust, soil, and other contaminants from entering the well casing.

E. Rail Spur: The rail spur will be left intact. The rail spur must be cleared of radiological material until gamma readings of twice background or less are achieved. The Quirk loading dock will be demolished and hauled to the pits.
Conclusions - Based on memoranda, discussions with M. Sarracino and an OAS field inspection, some features shown which were anticipated to be kept or salvaged were found to be of very poor condition. While not in strict compliance with the ROD, the demolition and disposal of additional facilities in no way impairs the environmental integrity of the project. Therefore, this is considered a non-substantive variance from ROD requirements.
Recommendations – No further activities are recommended.

7. DRILL HOLES All drill holes will be plugged according to the State Engineer's requirements. A 5-foot surface concrete plug will also be placed in each hole. Any cased holes will have the casing cut off at the surface. In addition, areas around drill holes will be seeded. Any exploration roads not wanted by the Pueblo will be reclaimed.
Conclusions - It is unclear what happened to the drill holes. No drill holes were found by CSM and that work unit was closed out on approval of all three parties. Therefore, this is considered a non-substantive variance from the ROD requirements.
Recommendations – No further activities are recommended at this time.

8. UNDERGROUND MODIFICATIONS A. Ventilation Holes: Vent holes will be backfilled with waste material (Dakota Sandstone and Mancos shale) to within six feet of surface. Surface casing will be removed, steel support pins installed in walls of vent holes, and sealed with a six-foot concrete plug from backfill to surface. Areas around vent holes will be contoured and seeded.
Conclusions - It is unclear how the vent holes were closed and there are no records of how they were closed. Monthly reports indicated that the vent holes were being closed, and the work unit was closed out on approval of all three parties. Therefore, this is considered in compliance with the ROD requirements.
Recommendations – No further activities are recommended at this time.
B. Adits and Declines: A concrete bulkhead will be constructed approximately 680 feet below the portal of P-10 decline. The decline will be backfilled from bulkhead to ground surface with Dakota Sandstone and Mancos shale. Sufficient material will be placed over the portal to allow for compaction and settling. The ground surface above the buried portal will be sloped and then top-dressed and seeded. The Alpine mine entry will be bulkheaded and backfilled. Mine entries not previously plugged by backfilling will be covered. Additionally, the H-1 mine adits will be bulkheaded and backfilled and the adits at the P-13 and NJ-45 mines will be backfilled.
Conclusions - It is unclear how the mine entries were closed. But the work units were

closed out on approval of all three parties. Because all three parties approved an alternate closure method, it is presumed that the intent of the ROD was met. However, the potential for subsidence may still exist.

Recommendations - Continue to monitor the P-10 and P 2/3 areas for subsidence. Closure methods apparently presented some potential for a "controlled accident", as was stated in the Landmark Reclamation report referenced above.

9. REVEGETATION METHODS

A. Top Dressing:

Following final sloping and grading, pit bottoms will be top dressed with 24 inches, waste dumps with 18 inches, and all other areas within the minesite with 12 inches of material composed primarily of Tres Hermanos Sandstone (stockpiles at three locations within the minesite). In order to meet top dressing volume requirements for the northern portion of the minesite, additional material may be obtained from a topsoil borrow area in the Rio Moquino floodplain comprising 44 acres. For the southern portion of the minesite, additional topsoil borrow material located east of J and H dumps may be needed. Following topsoil removal, disturbed borrow areas will be contoured, fertilized, seeded, and mulched.

B. Surface Preparation:

After applying top dressing, areas to be planted will be fertilized, followed by disking to a depth of 8 inches and then contour furrowing.

C. Seeding and Seed Mixtures:

Before seeding operations begin, the entire minesite will be fenced to prevent livestock grazing. In most situations, seed mixtures will be planted with a rangeland drill. Broadcast seeding combined with hydromulching may be used on inaccessible sites or if determined to be more feasible than drilling. For both methods, the seed mixture will consist mainly of native plant species possessing qualities compatible with post grazing use and adapted to the local environment (Tables 3-10 and 3-11; FEIS). Following drill seeding, straw mulch will be applied at about 2 tons per acre, and crimped into place with a notched disk.

D. Revegetation Success:

Using the Community Structure Analysis (CSA) or comparable method, plant establishment will be considered successful when revegetated sites reach 90 percent of the density, frequency, foliar cover, basal cover, and production of undisturbed reference areas (but not sooner than 10 years following seeding). Livestock grazing will be prevented until 90 percent comparability values are met. At the end of the 10-year monitoring period, if an unsuccessful trend is shown, retreatment may be necessary to achieve success criteria. In the pit bottoms, vegetation will be sampled annually for radionuclides and heavy metal uptake.

Conclusions - The Jackpile Reclamation Project post reclamation vegetation monitoring program deviated from the requirement of the Record of Decisions. This was due to evolution in the methodologies developed, accepted and routinely accepted in the scientific community in determining vegetative success. The monitoring met the intent

of the ROD in determining vegetation success, in that the mine was very successfully revegetated based on important vegetation parameters of cover and productivity. The revegetation did not meet the strict numerical standards of the ROD, but had vigorous and productive plant communities with desirable perennial grasses and shrubs. The condition of post-reclamation vegetation is very good to excellent, and the reclaimed mine has stable and self-sustaining diverse ecosystems, and good habitat for local wildlife. Trends in vegetation are stable for plant diversity and health.

Item 9-D of the ROD requires pit bottom vegetation be sampled annually for radiological and heavy metal uptake for a period of ten years. This was not done.

Recommendations - Vegetation uptake should continue to be monitored periodically in the future, especially in the pit bottoms. It has been suggested that monitoring be undertaken the next year and possibly every five years after next year; especially in the pit bottoms and in the North Paguate pit in particular.

10. MONITORING

The monitoring period will vary for each parameter. Existing monitoring activities to be continued will include meteorologic sampling, air particulate sampling, radon sampling (ambient), radon exhalation sampling, gamma survey, soil and vegetation sampling, water monitoring, and subsidence. In addition, the monitoring program will be expanded to include: radon daughter levels (working levels) in any remaining mine buildings, and groundwater recovery levels/salt buildup in the open pits. The groundwater monitoring period will be of sufficient duration to determine the stable future water table conditions. Refer to Table I-5 of the FEIS for details of the monitoring plan as described under the Preferred Alternative.

a. Meteorologic

Conclusions - Meteorologic monitoring was reportedly conducted during reclamation. There is, however, no data for monitoring conducted during that time. Meteorologic monitoring data was collected during reclamation as was appropriate. However, recurring data collection equipment problems resulted in discontinuous data collecting during the post-reclamation period. At least two different monitoring equipment suppliers were tried, but the power supply problems and problems with livestock destroying the equipment continued.

Recommendations – No further activities are recommended.

b. Air Particulates

Conclusions - The BIA Contracting Officer (CO) and Pueblo of Laguna reportedly agreed that it had been adequately demonstrated that the goals and objectives of the monitoring function had been met and agreed to discontinue the particulate sampling.

Recommendations – No further activities are recommended.

c. Ambient Radon

Conclusions - All recorded radon gas measurements were consistently below the limit of 3.5 pCi/L set by the ROD. Because of the consistently low measurements it was mutually agreed to phase out this requirement.

Recommendations – No further activities are recommended.

d. Radon Daughter Levels

<p>Conclusions – No records of radon daughter level monitoring in remaining mine buildings were located. A radon daughter limit of 0.03WL working level was the specified threshold for this parameter. This is potentially non-compliant with the ROD. However, the buildings were reportedly razed at the start of reclamation. Therefore, compliance could not have been conducted or expected.</p>
<p>Recommendations – It is not expected, but if any of the remaining mine buildings have residual Uranium series contaminants (U, Ra 226) and the air in the buildings is relatively stale, monitoring is advised prior to extended occupancy.</p>
<p>e. Radon Exhalation</p>
<p>Conclusions - This monitoring requirement was eliminated by design at the time of monitoring program development, so while the letter of the ROD was not met, the elimination of this monitoring item was authorized when the monitoring program was adopted.</p>
<p>Recommendations – No further activities are recommended.</p>
<p>f. Gamma Survey</p>
<p>Conclusions – Based on this radiological measurement review, the following conclusions can be drawn:</p> <ul style="list-style-type: none"> • Gamma radiation monitoring levels were consistently below the 28 µR/hr requirement, or lower, and a continuous monitoring program was not warranted. • The gamma radiation monitoring requirement stated that a ground survey, plus a final aerial survey, was to be conducted. The monitoring was to be conducted before seeding and after reclamation was completed. Monitoring was conducted before seeding, but the final aerial survey was not performed. • It is recommended that a final ground survey, or final aerial survey, be conducted, especially on the access roads, pit bottoms and former protore piles sites to verify that these areas meet the 28 µR/hr requirement.
<p>Recommendations - Based on these conclusions, the following recommendations can be made:</p> <ul style="list-style-type: none"> • Gamma radiation levels should be checked at least one more time to verify that reclaimed areas are meeting the standard of 28 µR/hr. • The reclaimed mine can be released from any requirement for radon gas measurements, and should present no hazards for human health. • The results of the process and sampling during the current and previous radiation monitoring should be reviewed. <p>Gamma radiation levels on the access roads, pit bottoms and former protore pile sites should be checked at least one more time, and in the future if the topography changes, to verify that those areas meet the 28 µR/hr requirement.</p>
<p>g. Soil</p>
<p>1) Topsoil</p>
<p>2) Radiologicals and Heavy Metals</p>
<p>3) Salt Buildup</p>
<p>Conclusions – The topsoil, radiological and metals monitoring requirements of the ROD have been met. The salt buildup and impact to grazing has not been met.</p>
<p>Recommendations - The lack of salt monitoring represents non-compliance with the ROD requirements, however, the presence of well established vegetation would appear to indicate that salt buildup is not occurring. It is recommended that the pit bottom soils</p>

be analyzed for salt build up, and in the future if it appears that salt buildup is occurring.
h. Radionuclide and Heavy Metal Uptake into Vegetation
Metals
Radionuclides
Conclusions - The Jackpile Reclamation Project vegetation uptake-monitoring program deviated from the requirement of the ROD in that heavy metals and radionuclides were not measured for ten consecutive years after reclamation was completed. Vegetation had low levels of metal and radionuclide uptake based on sampling and laboratory analysis. It is believed that vegetation growing on the reclaimed mine presents a minimal potential for hazards to domestic livestock or human health due to the low or normal concentrations of metals and radionuclides.
Recommendations - As previously mentioned in ROD Item 9, it has been recommended that uptake monitoring be undertaken next year and possibly on five-year intervals thereafter in the pit bottoms and particularly in the North Paguate pit.
i. Water Quality
Conclusions - Based on this review it is concluded that the intent of the ROD was met for water quality sampling, but there are some rather large data gaps. Conclusions cannot be drawn as to environmental impacts and long term health risks associated with water quality at the closed mine. The results of the radiological analyses of the monitoring well, surface water and particularly the pit wells, indicated inconsistencies in the data which should be resolved. The results of some of the pit well samples indicate levels that need to be evaluated and confirmed as soon as possible.
The four data gaps 1) the depth to water measurements were reportedly recorded in order to calculate the volume of water to be purged prior to sampling of the wells, but the record of those depths was incomplete, 2) the Jackpile pit wells were not installed until 2007, 3) the ponded water was not sampled and analyzed until 2007 (ponds were not anticipated during reclamation; they appeared in the latter half of the reclamation monitoring), and 4) a downgradient boundary well in the Jackpile Sandstone was not installed (the Jackpile Sandstone is reportedly not present at the boundary), collectively represent a major deviation from the ROD and is therefore, non-compliant .
Recommendations - Based on these observations, the following recommendations can be made:
<ol style="list-style-type: none"> 1. Continue sampling Jackpile pit wells, and install a discretionary well(s). 2. Install a discretionary well near the downgradient boundary. The location(s) of any discretionary well(s) should be selected in order to assess downgradient groundwater conditions. Two areas that could be considered for this purpose are 1) upgradient from the Rio San Jose and 2) at the Mesita Dam. The downgradient monitoring wells(s) should be constructed so that the screened interval allows for both environmental compliance monitoring, as well as water table elevation measurements. The existing monitoring wells MW-5 and MW-6 were apparently screened in the bottom 10 feet for water level measurement purposes only. 3. Continue sampling ponded water within pits. 4. Sample the ponded water at the north end of the site outside the Jackpile pit at least one more time. This pond extends onto the trust lands to the north where

<p>domestic cattle graze. The pond causes waste piles to be saturated and could lead to the release of contaminants from the waste pile.</p> <ol style="list-style-type: none">5. Monitoring should continue for all the wells and surface waters until a risk assessment has been completed. Continued monitoring of surface water may be necessary to protect fowl and animals. Parameters which should be monitored include field parameters, major cations and anions, manganese, total dissolved solids, arsenic, fluoride, lead, gross alpha, radium 226, uranium (total), gross beta and Po-210. At that time sample locations can be further evaluated to determine if the monitoring can be further limited.6. Water usage should be prohibited pending the results of additional sampling activities, QA/QC of previous lab results and the findings of the proposed Risk Assessment.7. With the completion of sampling, data should be evaluated as to its accuracy. The laboratories should be required to perform cation-anion balances and if not within acceptable ranges, the samples should be redone.8. A Quality Control/Quality Assurance analysis of all general chemistry, chemical and radiological reports and results needs to be conducted to evaluate the sampling procedures and analytical results. This should be followed by re-sampling of the water.9. A risk assessment should be performed to determine the potential hazards and risks of the high levels of gross alpha, radium 226, and uranium in most samples, especially in wells in fill material and areas of public access. A risk assessment is needed prior to Resource and Land Use planning for the mine site.10. With both surface water and groundwater samples showing some level of contamination, an evaluation should be made to determine if any contaminants have migrated beyond the compliance boundary. A compliance boundary must first be established.
<p style="text-align: center;">➤ Subsidence</p>
<p>Conclusions - The new highway was never closed for extended periods and the public is <i>not required</i> to use Old NM 279, so the letter of the ROD was met even though no monitoring took place.</p>
<p>Recommendation – Periodic inspection of Old NM 279 is recommended for subsidence and erosion.</p>
<p style="text-align: center;">➤ Ground Vibration</p>
<p>Conclusions - The blasting in the South Paguate Pit was carefully monitored and formal reports were issued. There was a damage assessment performed in the Village of Paguate where considerable damage was documented. This was followed by inspections of other pit highwalls revealing considerable integrity of highwalls and few expected safety issues related to letting the areas erode naturally. The decision by POL and BIA was to forego further blasting of highwalls, but to visually inspect the highwalls for safety issues.</p>
<p>Recommendations - A field assessment of the highwalls should be made to determine the hazard potential, if the walls are eroding safely or if not then if additional fencing or other corrective measures are required during the erosion process. If significant hazard potential is present, other means of slope reduction should be evaluated, such as ripping, or alternatively, localized berming or other protective measures may be warranted.</p>

11. SECURITY

Control of minesite access and security will continue during reclamation and monitoring activities. However, security during the monitoring phase will require cooperation from Pueblo of Laguna and BIA to prevent livestock grazing on revegetated sites.

Conclusions – These requirements are addressed previously in the report. Additional sampling is required especially in the open pits and ponded water. Risk assessment may be required before grazing and other uses are allowed.

Recommendations – Immediate re-sampling of the pit water and ponded water is recommended. Evaluation of the radiological data is recommended.

12. RECLAMATION COMPLETION

Reclamation will be considered complete when revegetated sites reach 90 percent of the density, frequency, foliar cover, basal cover, and production of undisturbed reference areas (but not sooner than 10 years following seeding). In addition, gamma radiation levels must be no greater than twice background over the entire mine site. Outdoor radon 222 concentrations must be no greater than 3 pCi/l. Radon daughter levels (working levels) in any remaining surface facilities must not exceed 0.03WL.

Conclusions – These requirements are addressed previously in the report. See previous discussions concerning revegetation, gamma radon, radon and radon daughter levels in Sections 9 and 10. Alternative methods used to survey vegetation indicate the revegetation was successful.

Recommendations – Please refer to previous recommendations concerning revegetation, gamma radon, radon and radon daughter levels in Sections 9 and 10.

13. POST-RECLAMATION LAND USES

Limited livestock grazing, light manufacturing, office space, mining and major equipment storage will be allowed. Specifically excluded are habitation and farming.

Conclusions – All *non-compliant* and *potentially non-compliant* issues need to be resolved before recommendations and discussions concerning long-term use can be undertaken.

Recommendations – This topic should be discussed with POL after all compliance issues have been resolved, recommended sampling and analysis completed, and risk assessment determinations have been made. Land use should be restricted, as it currently is, until all compliance issues are resolved.

APPENDIX A

**COMPARATIVE TABLES OF
CONTRACTOR BREAKOUT SCHEDULES
AND WORK ACTIVITIES**

TABLE A-1 Jackpile-Paquate Uranium Mine ROD Requirements, Assumed Resources and Actual References

ROD Requirement		Verify	Assumed Resources Available	Action	Actual Confirming References	
1 Pit Bottoms						
1A	Backfill Levels	Backfill to 10 feet above gw recovery levels	Verify meeting elevations proposed in FEIS	FEIS, App A, Fig. A-1 Proposed backfill elevations for 4 pits	Compare GW elevation to Fig A-1, check for >10 feet	Looking for GW elevation data in pit wells from post closure monitoring
			Check Actual GW recovery elevations	Before and After backfill elevation survey data	Compare survey data to gw elevation data	+ Have surveyed ground elevations at pit wells
				Remediation Report	Document activites referenced in Remed. Report	No Remediation Reports Generated
				Aerial Photos	Confirm no open water from recent aerals	No open water from recent aerals, but Open Water in All Pits during summer 2006
1B	Backfill Materials	Backfill Materials: protore, waste dump H&J, additional waste dump and stream channel clearing/sloping.	Verify acceptable fill material, cover material, and depths used	Remediation Report - Backfill and Cover	Document activites referenced in Remed. Report	Work Unit 2E1- Movement of Backfill Material (Closed NP 3/91, SP 12/91 & JP betw 3/92 and 12/94)
		Cover Material - 3 feet overburden and 2 feet topsoil		Aerial Photos	Compare Volumes removed at dumps/other places and volumes placed in pit according to remediation documents	Work Unit 2E3- Cover Placement (closed JP 4/93-6/96, NP 4/91 - 12/92 & 8/91 - 3/92)
				Trench or Coring Logs	Review trenching/coring logs	Confirmation Boring Grids
				Remediation Report	Document activites referenced in Remed. Report	No Remediation Reports Generated
1C	Stabilization	< 3:1 slopes	Verify Slopes		Inspect Site - look for erosion	
		surface water control berms	Check surface water control		Photo document site	Work Unit 2E2 - Closed 9/91-6/95
		surface runoff to small retention basin	Inspect for erosion, subsidence,veg. cover etc.			
		shaping, contouring, reseeding				
1D	Fencing	Sheep -proof fencing of pit bottoms		Jackpile		Work Unit 2S5J02 closed 12/91
				N Paguate		Work Unit 2S5N02 closed 12/91
				S. Paguate		Work Unit 2S5S02 closed 12/91
				Construct Permanent Fencing All Areas		Work Unit 2S5J09 Active 6/95 last monthly report)

ROD Requirement	Verify	Assumed Resources Available	Action	Actual Confirming References
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2 Pit Highwalls

2A	Jackpile	Cut top 15' highwall to slope of 45 degrees	Verify slopes	FEIS, App. A, Fig. A-7	Compare to planning diagram	Work Unit 2E5J01- No Charges
		Soil and unconsolidate material to slope to 3:1	verify loose material removal	Remediation Report	Document activities referenced in Remed. Report	No Remediation Report
		Scale remaining to remove loose debris			Inspect and photograph site	Work Unit 2E5J02 - No Charges
		Fence Highwall with 6 foot chain link				Work Unit 2S5J02 closed 12/91; BUT No visible highwall fencing
2B	North Paguate	Cut top 15' highwall to slope of 45 degrees	Verify slopes	FEIS, App. A, Fig. A-7	Compare to Planning diagram	Work Unit 2E5N01 closed 12/91; BUT no highwall work done in this highwall area
		Soil and unconsolidate material to slope to 3:1	verify loose material removal	Remediation Report	Document activities referenced in Remed. Report	No Remediation Report
		Scale remaining to remove loose debris			Inspect and photograph site	Work Unit 2E5N02 - closed 12/91; BUT no work done in this highwall area
		Fence Highwall with 6 foot chain link	verify fence			Work Unit 2S5N02 closed 12/91; BUT No work done in this highwall area
2C	South Paguate	Cut top 15' highwall to slope of 45 degrees	Verify slopes	FEIS, App. A, Fig. A-7	Compare to Planning diagram	Work Unit 2E5S01- closed 12/91
		Soil and unconsolidate material to slope to 3:1	verify loose material removal	Remediation Report	Document activities referenced in Remed. Report	No Remediation Report
		Scale remaining to remove loose debris			Inspect and photograph site	Work Unit 2E5S02 - closed 12/91
		Fence Highwall with 6 foot chain link	verify fence			Work Unit 2S5S02 closed 12/91

3 Waste Dumps

	H & J	Relocate to Jackpile for fill		remediation report	Document activities referenced in Remed. Report	Work Unit 2E1--- and 2E2---
		Slope to 3:1; exceptions in Table I-4	verify slopes	FEIS Table I-4, App. A Fig A-9	Inspect and photograph site	Relates to moving waste stockpiles, cutting and grading
		Exposed Jackpile Sandstone- covered by 3 feet overburden and 18 inches topsoil	verify cover	Cores or trenching logs	Compare Volumes removed at dumps/other places and volumes placed in pit according to remediation documents	Check for variation authorization
		Without Jackpile Sandstone - cover with 18 inches topsoil		Aerial Photos		
		Contour per instructions		Maps of Dumps		Work Unit 2T2---

ROD Requirement	Verify	Assumed Resources Available	Action	Actual Confirming References
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4 Protore Stockpiles

						Work Unit 2E2J04
						Work Unit 2E1---
		All protore will be used as backfill material in pit areas		Maps	Document activities referenced in Remed. Report	No Remediation Report
				Aerial Photos	Inspect and photograph site	
		Backfill will be covered with 3 feet of overburden and 2 feet of TH Sandstone or alluvial material		Cores or trench logs	Compare Volumes removed at dumps/other places and volumes placed in pit according to remediation documents	

5 Site Stability and Drainage

						Work Unit 2E6N01A
5A	Stream Stability	Remove contaminated and fill material within 100 feet of Rio Paguate west of confluence with Rio Moquino and place in pits.	Verify Removal	Remediation Report	Document activities referenced in Remed. Report	
		On the Rio Moquino, pits S,T, U, N and N2 will be pulled back 50 feet from centerline stream channel. Toes of these dump areas will be armored with riprap	Verify channel cleared and riprap	Maps	Compare Volumes removed at dumps/other places and volumes placed in pit according to remediation documents	
		Construct concrete drop structure on Rio M. 400 feet above confluence with Rio P.	Verify drop structure construction	Aerial Photos	Inspect and photograph site	Work Unit 2S5J02A
5B	Arroyo Headcutting	Arroyos south of dumps I,Y and Y2 and arroyo west of dumps FD-1 and FD-3 will be armored as shown in FEIS, App.A, A-13	Verify armoring	Maps, Aerial Photos, Remediation Report	Inspect and photograph site	Headcutting ceased when a sandstone outcropping was encountered, no need for this work.
		Other headcuts encountered during reclamation will be stabilized by armoring		FEIS, App.A, A-13	Document activities referenced in Remed. Report	
5C	Blocked Drainages	Remove dump J and protore stockpiles SP-17BC and SP-6-B will be removed to unblock ephemeral drainage on south side of mine site.	Verify removals	Maps, Aerial Photos, Remediation Report	Inspect and photograph site	Work Unit 2E1J04
		Two blocked drainages north of FD-1 and F dumps will remain blocked			Document activities referenced in Remed. Report	Observed that Drainages remain Blocked

ROD Requirement	Verify	Assumed Resources Available	Action	Actual Confirming References
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6 Surface Facilities/Structures

						N. Pagate Work Unit 2S3N01 closed 2/90
6A	Lease No. 1 (Jackpile Lease)	Demolish all buildings except: geology bldg, miner training center and buildings at Old Shop and Open Pit offices.	Verify demolition	Maps, Aerial Photos, Remediation Report	Inspect and photograph site	Jackpile Work Unit 2S3J01- activity 2/90 thru 12/90 no closure date
		The land surfaces (except pit highwalls and natural outcrops) will be cleared of radiological material to < 2X background gamma	Verify gamma levels	Review gamma screening	Document activities referenced in Remed. Report	
		Grade and seed these areas	Verify revegetation			
6 B	Lease No. 4	All facilities and structures at P-10 Mine and New Shop will remain		Maps, Aerial Photos, Remediation Report	Inspect and photograph site	South Pagate Work Unit 2S3S01 active 8/89 thru 10/91 no closure date
		O&M Equipment will be removed	Verify removal	Review gamma screening	Document activities referenced in Remed. Report	
		Permanenet structures and land surfaces (except pit highwalls and natural outcrops) will be cleared of radiological material to < 2X background gamma	Verify gamma levels			
		Grade and seed these areas	Verify revegetation			
		Non salvageable buildings will be demolished and placed in pits				
6 C	Access Routes	Four major roads within mine site will be cleared of radiological material	Verify contamination removal	Maps, Aerial Photos, Remediation Report	Inspect and photograph site	Construction Work Units: 2S5 - no activity
		All other roads (except Lease No. 4) will be removed, graded and seeded.	Verify removal and reveg.	Gamma screening	Document activities referenced in Remed. Report	Kept only roads necessary for monitoring and maintenance activities.
6 D	Water Wells	Jackpile No. 4 well, P-10 Well, New Shop Well and 3 wells near housing areas and their sheltering will be left. All wells will be _____?_____ to prevent dust, soil and other contaminant from entering well casing	Verify the well locations and protections		Inspect and photograph site	No work units, MS related what wells were dismantled and what appertenances were left at each site.
		Pumps, risers, wiring and storage tanks will be removed	verify removal of these features		Document activities referenced in Remed. Report	
		Monitoring wells will remain.				

6 E	Rail Spur	The rails spur will be left intact but cleared of radiological material to < 2X gamma	Verify railway contamination levels	Maps, Aerial Photos, Remediation Report	Inspect and photograph site	Visual indicate remains, no specific work unit.
		Quirk loading dock will be demolished and disposed of in the pits.	verify removal and disposal	Gamma screening	Document activities referenced in Remed. Report	Visual indicated removed, No specific work unit.

7 Drilling Holes

		All drill holes will be plugged according to the State Engineer's requirements	Verify well closures	Maps, Aerial Photos, Remediation Report	Inspect and photograph site	Work Unit 2S1S05 closed 3/90
		5 foot concrete plug at surface and cut flush to surface, reseeded			Document activities referenced in Remed. Report	
		Unwanted access roads will be removed	Verify removals and Pueblo wishes			

8 Underground Modifications

8 A	Ventilation Holes	Closed per instructions	Verify Closures	Maps, Aerial Photos, Remediation Report	Inspect and photograph site	Work Unit 2S1S04 closed 3/92
					Document activities referenced in Remed. Report	
8 B	Adits and Declines	P-10 will have a concrete bulkhead constructed 690 feet below portal. It will be backfilled from bulkhead to Groundsurface with Dakota Sandstone and Mancos Shale. It will be sloped and seeded	Verify Closure	Maps, Aerial Photos, Remediation Report	Inspect and photograph site	Work Unit 2S1S02 closed 2/92
		Alpine Mine Entry will be bulkheaded and backfilled.	Verify Closure	Maps, Aerial Photos, Remediation Report	Document activities referenced in Remed. Report	No work unit applied to Alpine
		H-1 Mine adits will be bulkheaded and backfilled	Verify Closure	Maps, Aerial Photos, Remediation Report		Work Unit 2S1S03 closed 2/90
		P-13 and NJ-45 Mine Adits will be backfilled	Verify Closure	Maps, Aerial Photos, Remediation Report		Work Unit 2S1S01 closed 12/91
		Minre entries not previously plugged by backfilling will be covered.				
					Adit PW-2/3	Work Unit 2S1N01 closed 3/90
					JP-PS-46 Enntries	Work Unit 2S1J02 no activity
					JP-SS-50 Entries	Work Unit 2S1J01 no activity

		Assumed		Actual Confirming
ROD Requirement	Verify	Resources Available	Action	References

9 Revegetative Methods

9A	Top Dressing	Instructions	Verify methods used	Maps, Aerial Photos, Remediation Report	Document activities referenced in Remed. Report	
9B	Surface Preparation					
9C	Seeding and Seed Mixtures					
9 D	Revegetation Success	At 10 years or later, 90 % density, foliar cover, basal cover, and production of undisturbed reference areas per CSA or comparable method	Perform CSA or comparable	Maps, Aerial Photos, Remediation Report	Document activities referenced in Remed. Report	Check ROD against Construction Specifications and Memos with Changes
		Livestock grazing will be prohibited until 90 % CSA met			Perform CSA or comparable	Work Units 2R1---activity Oct 1991 through Jun 1995
		At end of 10 year monitoring if unsuccessful, retreatment may be required			Make recommendations on areas in need of revegetation	
		Pit bottoms must be sampled annually for radionuclide and heavy metals	Annual Sampling	Annual vegetation Monitoring Reports	Review annual Veg monitoring reports	Review Existing Reports and 2006 Data

10 Monitoring

	Monitoring Plan	FEIS, Table I-5 details monitoring plan	Verify monitoring requirements met	Monitoring Reports	Review data and compare to clean up standards	Compile and review lab data
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11 Remediation Completion

	Vegetation	90 % CSA parameters	Verify levels met	Monitoring Reports	Review data and compare to clean up standards	No Clean Up Standards Set
	Gamma Radiation	< 2x background over entire site				
	Outdoor Radon 222	< 3 pCi/l				
	Radon daughters	< 0.03				

TABLE A-2 Reconcile Monthly Maps with Draft EIS Map Areas

a.) EIS Report Includes "Jackpile Paguate Mine Site Visual A"

This figure contains a map with waste protore and topsoil areas designated

b.) Construction Work Areas taken from Monthly Report Maps

PROTORE, WASTE AND TOPSOIL PILES

Planning Areas (a)	Construction Work Unit Areas (b)	What Done?	Planning Areas (a)	Construction Work Unit Areas (b)	What Done?	Planning Areas (a)	Construction Work Unit Areas (b)	What Done?
JACKPILE			NORTH PAGUATE			SOUTH PAGUATE		
Top Soil								
TS-1	JP-SB-53	Used for TS cover	TS-2A	NP-SB-26	Used for TS cover	TS-3	SP-SB-42	Used for TS cover
B	JP-WT-16	Used for TS cover	TS-2B	NP-SB-27	Used for TS cover			
			West RM-104	JP-SB-64	Not used			
Waste								
U	JP-WO-14	Left in place covered	T, S	NP-WO-01	Left in place	Q,R	SP-WT-03	Left in place covered
A&B	JP-WS-15	Used for shale cover		NP-WS-31	Used for shale cover		SP-WO-04	Left in place covered
FD-3	JP-WO-18 (SW)	Left in place covered	N,N2	NP-WO-02	Left in place	South Dump	SP-WS-06	Left in place covered
FD-1	JP-WO-66	Left in place covered		NP-WM-12	Left in place	SP Pit Waste	SP-WS-11	Left in place covered
	JP-WO-66A	Left in place covered		NP-DN-11	Left in place		SP-WO-10	Left in place covered
	JP-WO-18C	Left in place covered	N	NP-WT-10	Used for Soil cover		SP-WM-12	Left in place covered
	JP-WO-18 (North)	Left in place covered					SP-WO-13A	Left in place covered
	JP-WS-17	Used for shale cover					SP-WO-14	In pit Used for backfill
	JP-WS-19A	Left in place covered					SP-WO-13B	Left in place covered
	JP-WS-19C	Left in place covered					SP-WS-17	Used for shale cover
FD-2	JP-WS-01	Left in place covered					SP-WT-16	Left in place
C,D,E,F,G	JP-WT-02	Left in place					SP-WS-18A	Left in place covered
	JP-WO-70	Left in place					SP-WS-18C	Left in place covered
H	JP-WO-06	Left in place covered					SP-WT-19	Used for soil cover
X,I,Y,Y2	JP-WO-03B	Left in place covered					SP-WS-20	Used for shale cover
	JP-WO-03	Left in place covered					SP-WS-37	Left in place covered
	JP-WO-04	Left in place covered					SP-WT-15	Used for soil cover
	JP-WO-07	Left in place covered					SP-WM-36	Left in place covered
W	JP-WO-11 (South)	Left in place covered					SP-WS-07	Used for shale cover
	JP-WO-12	Left in place covered					SP-WS-08	Used for shale cover
	JP-WS-08	Left in place covered					SP-WS-09	Used for shale cover
	JP-WO-10	Left in place covered					SP-WS-18B	Left in place covered
	JP-WO-09	Left in place covered				L, K	SP-WT-05	Left in place covered
V	JP-WS-13	Left in place covered					SP-WO-38	Left in place covered
	JP-WO-11 (North)	Left in place covered						
	JP-WO-20	Left in place covered						
J	JP-WO-05	Left in place covered						
Jackpile Pit Waste	JP-WO-72	Used for backfill						
Protore								
SP-6-A	JP-PS-24	Hauled to JP-OP-41	SP-2-C	NP-PS-17	Hauled to NP-OP-20	SP-1-A	SP-PS-01	Hauled to NP-OP-20
SP-6-B	JP-PS-25	Hauled to JP-OP-41	1B	NP-PS-18	Hauled to NP-OP-20	4-1	SP-PS-02	Hauled to SP-OP-34
SP-1, J-1A, J-1-A, JLC	JP-PS-22	In JP-OP-41 covered	10, SP-2-D, SP-1-C	NP-PS-15	Hauled to NP-OP-20	PLG		In SP-OP-34 covered
17-E	JP-PS-23	Hauled to JP-OP-41		NP-PS-16	Hauled to NP-OP-20	PLG-1		In SP-OP-34 covered
J2	JP-PS-26	Hauled to JP-OP-41	2E	NP-PS-14	Hauled to NP-OP-20	1-D		In SP-OP-34 covered
J1	JP-PS-27	Hauled to JP-OP-41	1E	?	In NP-OP-20 covered			
SP-17BC	Off Work Unit Map	Hauled to JP-OP-41	SP-1	NP-PS-13	Hauled to NP-OP-20			
			SP-1-A	SP-PS-01	Hauled to NP-OP-20			

SHALE COVER OPERATIONS

JACKPILE	NORTH PAGUATE	SOUTH PAGUATE
None Available	NP-D1 NP-D2 NP-D3 NP-D4 NP-D5 NP-D6 NP-D7 NP-D8 NP-D9 NP-D10	SP-D1 SP-D2 SP-D3 SP-D4 SP-D5 SP-D6 SP-D7 SP-D8 SP-D11

TOPSOILCOVER

JACKPILE	NORTH PAGUATE	SOUTH PAGUATE
JP-D1 JP-D2 JP-D3 JP-D4A JP-D4B JP-D5 JP-D6 JP-D7	NP-D1 NP-D2 NP-D3 NP-D4 NP-D5 NP-D6 NP-D7 NP-D8 NP-D9 NP-D10	SP-D1 SP-D2 SP-D3 SP-D4 SP-D5 SP-D6 SP-D7 SP-D8
JP-D8A JP-D8B JP-D9A JP-D9B		SP-D10 SP-D11
JP-D11 JP-D12 JP-D13 JP-D14 JP-D15		

TABLE A-3 Jackpile ROD vs. Work Packages

Used Marvin's Closeout Summary Table and Added entries from Monthly Report "Detail for PTD"		Marvin's Closeout Dates	Coded for Various Pile Categories					ROD Categories	Relate Draft EIS Piles to Work Units
			Probe	Waste	Shale	Topsoil	Contam.		
	BACKFILLING								
Jackpile	J = Jackpile								EIS Protore, Waste & Topsoil Piles
2E1J01/01B	Haul Roads and Ramps thru PY93								
2E1J02	JP-PS-23 to Backfill (JP-OP-41)	Dec-92	P					1B	move Protore pile 17E
2E1J03	JP-PS-24 Pit Backfill (JP-OP-41)	Apr-93	P					1B	Move Protore Pile SP-6A
2E1J04	JP-PS-25 Pit Backfill (JP-OP-41)	Apr-93	P					1B	SC Partial - moved Protore SP6B
2E1J05	Pit Backfill JP-PS-26 (JP-OP-41)	Feb-92	P					1B	Move Protore J2
2E1J06	Pit Backfill JP-WO-10 (JP-OP-41)	Feb-92		W				1B	Move Waste W
2E1J07	JP-PS-27 to Backfill (JP-OP-41)	Dec-92	P					1B	Move Protore J1
2E1J08	JP-WO-07 Pit Backfill (JP-OP-41)	Apr-93		W				1B	Move Waste Piles X,I,Y,Y2
2E1J09	JP-WO-12 to Pit Backfill (JP-OP-41)	Jul-94		W				1B	Move Waste W
2E1J10	JP-WS-08 to JP-OP-41	Not Used		W				1B	Move Waste W
2E1J11	JP-WS-15 Pit Backfill (JP-OP-41)	Nov-94		W				1B	Move Waste A,B
2E1J12	JP-WO-71 Pit Backfill (JP-OP-41)	Sep-93		W				1B	
2E1J13	JP-WO-03 Pit Backfill (JP-OP-41)	Feb-92		W				1B	Move Waste Piles X,I,Y,Y2
2E1J14	JP-WS-13 & WO-20 Backfill (JP-OP-42)	Dec-92		W				1B	Move Waste V
2E1J15	Jackpile Haul Roads- Force Account								
North Paguate	N=North Paguate								
2E1N01	Build No Paguate Haul Roads	Nov-90							
2E1N02	Haul to Pit NP-PS-17	Sep-91	P					1B	Move Protore SP-2-C
2E1N03	NP-PS-18 to No.Paguate Pit	Nov-90	P					1B	Move Protore 1B
2E1N04	Haul NP-PS-14 to Pit	Feb-90	P					1B	Move Protore 2E
2E1N05	NP-PS-15 to No.Paguate Pit	Nov-90	P					1B	Move Protore 10,SP-2-D, Sp-1-C
2E1N06	NP-PS-16 to No. Paguate Pit	Nov-90	P					1B	Move Protore 10,SP-2-D, Sp-1-C
2E1N07	SP-PS-01 to No. Paguate Pit	Nov-90	P					1B	Move Protore SP-1-A
2E1N08	No Work Unit Assigned this WBS								
2E1N09	No Work Unit Assigned this WBS								
2E1N10	NP-WT-10 Pit Backfill	Sep-91		W				1B	Move Waste Pile N
2E1N11	Relocate NP-PS-13 to Pit	Feb-90	P					1B	Move Protore SP-1
2E1N12	Cut Slopes NP-OP-19	Feb-90							
South Paguate	S=South Paguate								
2E1S01	Construct Sp Haul Roads								
2E1S02	Pit Backfill SP-PS-02	Sep-91	P					1B	Move Protore 4-1
2E1S03	SP-PS-02 Additional Volume	Dec-91	P					1B	Move Protore 4-1

Used Marvin's Closeout Summary Table and Added entries from Monthly Report "Detail for PTD"		Marvin's Closeout Dates	Coded for Various Pile Categories					ROD Categories	Relate Draft EIS Piles to Work Units
			Prebre	Waste	Shale	Topsoil	Contam.		
									EIS Protore, Waste & Topsoil Piles
	DUMP SLOPING								
Jackpile	J = Jackpile								
2E2J01	JP-WO-11 Backfill	Jul-94		w				1B	Slope Waste V and W
2E2J02	JP-WT-16D Backfill	Jul-94		w				1B	
2E2J03	JP-WS-17 to Backfill (Dozers)	Dec-92		w				1B	Slope FD-1
2E2J04	JP-PS-22 Cut Slopes	Dec-92	p		p				Slope Protore SP-1, J-1A, J-1-A, JLG
2E2J05	Cut JP-WO-72 Slopes	Sep-92		w					Slope Jackpile Pit Waste
2E2J06	No Work Unit Assigned this WBS								
2E2J07	No Work Unit Assigned this WBS								
2E2J08	Cut JP-WS-01 Slopes	NC							Slope FD-2
2E2J09	Deleted (JP-WT-02A/02B/02C)								Slope C,D,F,G
2E2J10	JP-WO-73 Pit Backfill	Sep-93		w				1B	
2E2J11	No Work Unit Assigned this WBS								
2E2J12	JP-WO-06 Cut Slopes	Apr-93		w					Slope Waste e H
2E2J12	JP-WO-06 Cut Slopes	Sep-93		w					Slope Waste H
2E2J13	JP-WO-08 / WO-12 Cut Slopes	Apr-93		w					Slope Waste W
2E2J14	JP-WO-11 Cut Slopes	Feb-92		w					Slope Waste V & W
2E2J15	Cut Slopes JP-WS-15 (15A/15B Slopes)	Sep-91		w					Slope Waste A&B
2E2J16	JP-WO-05 Cut Slopes	Apr-93		w					
2E2J17	Cut JP-WT-16A/16B/16C/Slopes	NC		w					Slope Jackpile Pit Waste
2E2J18	Shale to JP-D4				s				
2E2J19	JP-WO-73 Pit Backfill	Apr-93		w				1B	
2E2J20	Cut Slope JP-WO-14	Dec-91		w					Slope Waste U
2E2J21	JP-WS-15A Cut Slopes	Feb-92		w					Slope A&B
2E2J22	JP-WS-19 B & C	Sep-92		w					Slope Waste FD-1
2E2J23	Cut JP-WS-19C Slopes			w					Slope Waste FD-1
2E2J24	Cut Slopes JP-WO-66	Sep-91		w					Slope Waste FD-1
2E2J25	Deleted (JP-WO-70)			w					Slope Waste C,D,E,F,G
2E2J26	JP-WO-18A / 66A Cut Slopes	Dec-92		w					Slope Waste FD-1
2E2J27	Cut Slopes JP-WO-18B & 66C	Sep-92		w					Slope Waste FD-1
2E2J28	JP-WO-18C / 66C	Dec-92		w					Slope Waste FD-1
2E2J29	JP-WO-03A Cut Slopes	Jul-94		w					Slope Waste X,I,Y,Y2
2E2J30	JP-WO-03B Cut Slopes	Sep-93		w					Slope Waste X,I,Y,Y2
2E2J31	JP-WO-04A Cut Slopes	Sep-93		w					Slope Waste X,I,Y,Y2
2E2J32	JP-WO-04B Cut Slopes	Sep-93		w					Slope Waste X,I,Y,Y2
North Paguate	N=North Paguate								
2E2N01	Cut Bench NP-WO-01	Feb-92		w					Slope Waste T&S
2E2N02	Cut Slopes NP-WO-02	Sep-91		w					Slope N, N2
2E2N03	Cut Slopes N P-WS-03	Sep-91		w					
2E2N04	Slope NP-WO-04	Nov-90		w					
2E2N05	Cut NP-WO-06 Slopes	NC							
2E2N06	Cut NP-WT-09 Slopes	NC							
2E2N07	Regrade NP-DN-22	Dec-91							
2E2N08	Cut Slopes NP-WM-12	Sep-91		w					Slope N, N2
2E2N09	Slope NP-HW-25	Nov-90							

Used Marvin's Closeout Summary Table and Added entries from Monthly Report "Detail for PTD"		Marvin's Closeout Dates	Coded for Various Pile Categories					ROD Categories	Relate Draft EIS Piles to Work Units
			Protore	Waste	Shale	Topsoil	Contam.		
									EIS Protore, Waste & Topsoil Piles
South Paguate	S=South Paguate								
2E2S01	Slope SP-WO-13A / WO-10	Nov-90		w					Slope SP Pit Waste
2E2S02	Cut Slopes SP-WS-17	Dec-91		w					Slope SP Pit Waste
2E2S03	Cut Slope SP-WO-13B & WS-18A	Dec-91		w					Slope SP Pit Waste
2E2S04	Cut SP-WO-14 Slopes	Feb-90		w					Slope SP Pit Waste
2E2S05	Cut SP-WS-18B Slopes	NC		w					Slope SP Pit Waste
2E2S06	Slope SP-WS-18C / WT-19	Nov-90		w					Slope SP Pit Waste
2E2S07	Slope SP-WT-03	Nov-90		w					
2E2S08A	SP-OP-34 Backfill (Force Account) SP-WT-06	NC		w				1B	slope Q&R
2E2S09	Cut SP-WO-38 Slopes	Feb-90		w					Slope L&K
2E2S10	SP-WS-06	Deleted		w					
2E2S11	Slope SP-WT-19A	Nov-90		w					Slope SP Pit Waste
2E2S12	Slope SP-WM-12 and WS-11	Nov-90		w					Slope SP Pit Waste
2E2S13	SP-WT-15A,B	Deleted							Slope SP Pit Waste
2E2S14	Backfill SP-OP-34 (D4-West)	Dec-91							
2E2S15	Slope SP-WT -16/37	Nov-90		w					Slope SP Pit Waste
2E2S16	Backfill SP-OP-34 (D4-East)	Dec-91						1B	
2E2S17	Backfill SP-OP-34 (SP-14)	Dec-91						1B	
2E2S18	Backfill SP-OP-34(Sh-2)	Dec-91						1B	
2E2S19	Misc. So. Paguate Sloping	Nov-90							
COVER PLACEMENT									
Jackpile	J = Jackpile								
2E3J01	Haul Soil from JP-SB-53 to D4 Soil Cover	Apr-93				T		1B	
2E3J02	Haul Soil from JP-SB-53 to D5 Soil Cover	Apr-93				T		1B	
2E3J03	Haul Soil from JP-SB-53 to D6 Soil Cover					T		1B	
2E3J04	Haul Soil from JP-SB-53 to D9A	Jul-94				T		1B	
2E3J05	Haul Soil from JP-SB-53 to D1	Nov-94				T		1B	
2E3J06	Haul Soil from JP-SB-53 to D3					T		1B	
2E3J07	Haul Soil from JP-SB-53 to D2					T		1B	
2E3J08	Haul Soil from JP-SB-64 to D7					T		1B	
2E3J08A	JP-WO-07 Pit Backfill	Sep-93		w				1B	Related to Piles X,J,Y,Y2
2E3J09	Haul Soil from JP-SB-64 to D11	Nov-94				T		1B	
2E3J10	Haul Soil from JP-SB-64 to D12 or D12A	Sep-93				T		1B	
2E3J11	Haul Soil from JP-SB-54 to D16	Sep-93				T		1B	
2E3J12	Haul Soil from JP-SB-54 to D15	Jul-94				T		1B	
2E3J12	Soil JP-D15	Sep-93						1B	
2E3J13	Soil to JP-D4	Jul-94						1B	
2E3J14	1990 (JP-SB-54)	Deleted				T		1B	
2E3J15	Topsoil to H-1 mine area	Dec-91				T		1B	
2E3J16	Soil to JP-D13	Jul-94						1B	
2E3J17	Soil JP-D8B							1B	
2E3J18	Haul Shale from JP-WS-19 to D4	NC			s			1B	
2E3J19	Haul Shale from JP-WS-15 to D1	NC			s			1B	
2E3J20	Haul Shale from JP-WS-15 to D2 Shale Cover	Apr-93			s			1B	
2E3J21	Haul Shale from JP-WS-15 to D7	NC			s			1B	
2E3J22	Haul Shale from JP-WS-15 to D11	NC			s			1B	
2E3J23	Haul Shale from JP-WS-15 to D12	Apr-93			s			1B	
2E3J23	Shale JP-D15	Sep-93			s			1B	
2E3J24	Haul Shale from JP-WT-02 TO D8A	Nov-94			s			1B	Haul Shale C,D,E,F,G
2E3J24	JP-WO-02	NC						1B	
2E3J25									
2E3J26	Shale Cover JP-D13	Jul-94			s				
2E3J27	Shale JP-D14 or D4	Sep-93			s			1B	
2E3J28	Haul Shale from JP-WT-02 to D15	Jul-94			s			1B	
2E3J29	Haul Shale from JP-WT-02 to D16	Sep-93			s			1B	

Used Marvin's Closeout Summary Table and Added entries from Monthly Report "Detail for PTD"		Marvin's Closeout Dates	Coded for Various Pile Categories					ROD Categories	Relate Draft EIS Piles to Work Units
			Protores	Waste	Shale	Topsoil	Contam.		
									EIS Protores, Waste & Topsoil Piles
North Paguate	N=North Paguate								
2E3N01	Haul Soil from NP-SB-61 to NP-D8	Sep-92				T		1B	
2E3N02	Haul Soil from NP-SB-26 to NP-D2	Sep-91				T		1B	
2E3N02	Soil Cover NP-D7	Sep-92						1B	
2E3N03	Haul Soil from NP-SB-27 to NP-D7	NC				T		1B	
2E3N04	Haul Soil from NP-SB-27 to D9	Feb-92				T		1B	
2E3N05	Haul Soil from NP-SB-27 to D6	Dec-92				T		1B	
2E3N06	Haul Soil from NP-SB-61 to NP-D9	Feb-92				T		1B	
2E3N07	Haul Soil from SP-DN-61 to NP-D4	Nov-91				T		1B	
2E3N08	Haul Soil from SP-DN-61 to NP-D1	Nov-91				T		1B	
2E3N09	Haul Soil from SP-DN-61 to NP-D3	Sep-91				T		1B	
2E3N10	Haul Soil from SP-DN-61 to NP-D5	Sep-91				T		1B	
2E3N11	Haul Soil from SP-DN-61 to NP-D10	Sep-92				T		1B	
2E3N12	Soil to NP-D6 (Benches)	Sep-92						1B	
2E3N13	Haul Shale Cover From NP-WS-31 to N P-D9	Feb-92			S			1B	Haul shale from T&S
2E3N14	Shale Borrow to N P-D4	Sep-91			S			1B	
2E3N15	Shale Borrow to NP-D5	Sep-91			S			1B	
2E3N16	Haul Shale from NP-WS-31 to NP-D8	Feb-92			S			1B	Haul shale from T&S
2E3N16	Shale Cover NP-D8	Sep-92			S			1B	
2E3N17	Haul Shale from NP-WS-31 to NP-D10	Sep-92			S			1B	Haul shale from T&S
2E3N18	Haul Shale From NP-WS-03 to NP-D3	Sep-91			S			1B	
2E3N19	Haul Shale From NP-WS-03 to NP-D3	Sep-91			S			1B	
2E3N20	No Work Package Assigned this WBS#								
2E3N21	Haul Shale from NP-WS-03 to NP-D1	NC						1B	
South Paguate	S=South Paguate								
2E3S01	Topsoil Soil Borrow SP-OP-35 (SP-D1) from SP-SB	Sep-91				T		1B	
2E3S02	Topsoil Soil Borrow SP=WS-17 (SP-D2) from SP-SB	Dec-91				T		1B	
2E3S03	Topsoil Soil Borrow to SP-D3 from SP-SB-44	Dec-91				T		1B	
2E3S04	Haul Soil from SP-SB-42 to SP-D4	Feb-92				T		1B	
2E3S05	Haul Soil from SP-SB-42 to SP-D5	Feb-92				T		1B	
2E3S06	Haul Soil from SP-SB-42 to SP-D6	Feb-92				T		1B	
2E3S07	Haul Soil from SP-SB-42 to SP-D7	Feb-92				T		1B	
2E3S08	Topsoil to SP-D8 from SP-SB-44	Dec-91				T		1B	
2E3S09	Topsoil to SP-D9 from SP-SB-42	Dec-91				T		1B	
2E3S10	Haul Soil from SP-SB-42 to SP-D10	Not Used						1B	
2E3S11	Topsoil to SP-D11 from SP-SB-42	Dec-91				T		1B	
2E3S12	Soil Cover to SP-D12 from SP-SB-43	Feb-92				T		1B	
2E3S13	Topsoil to SP-D1B from SP-SB-50	Nov-91				T		1B	
2E3S14	Shale Cover SP-WO-13A from SP-WS-17	Sep-91			S			1B	
2E3S15	Shale Borrow (SP-13B) from SP-WS-15	Not Used						1B	
2E3S16	Shale Borrow for SP-PS-01 from SP-WS-07	Sep-91			S			1B	Remove shale from SP Pit Waste for Cover
2E3S17	Shale Cover to SP-14 from SP-WS-07	Dec-91			S			1B	Remove shale from SP Pit Waste for Cover
2E3S18	Haul Shale Borrow from SP-WS-07 to SP-WO-04	Sep-91			S			1B	Cover Q,R with shale from SP Pit Waste
2E3S19	Haul Shale from SP-WS-07 to SP-D10	Nov-91				T		1B	Remove shale from SP Pit Waste for Cover
2E3S20	Haul Shale to SP-38 Shale from SP-WS-07	Sep-91			S			1B	Remove shale from SP Pit Waste for Cover
2E3S21	Haul Shale Cover from SP-WS-07 to SP- WO-10	Sep-91			S			1B	Remove shale from SP Pit Waste for Cover
	CONTAMINATED SOIL EXCAVATION								
Jackpile	J = Jackpile								
2E4J01	Haul JP-CS-36 to JP-OP-41 for Backfill	Feb-92						c	
2E4J02	Haul JP-CS-37/38 to JP-OP-41 Backfill	Dec-92						c	
2E4J03	No work Package assigned this WBS								
2E4J04	Combined into 2E4J02								

Used Marvin's Closeout Summary Table and Added entries from Monthly Report "Detail for PTD"		Marvin's Closeout Dates	Coded for Various Pile Categories					ROD Categories	Relate Draft EIS Piles to Work Units
			Probre	Waste	Shale	Topsoil	Contam.		
									EIS Probre, Waste & Topsoil Piles
North Paguate	N=North Paguate								
2E4N01	Haul Pit Backfill from NP-CS-24/23 to NP-OP-20	Sep-91					c		
2E4N01 A	N. Rio Paguate Backfill-East	Dec-91					c		
2E4N01 B	N. Rio Paguate Backfill-West	Dec-91					c		
South Paguate	S=South Paguate								
2E4S01	SP-SS-27/28, CS	NC							
2E4S01	FM S-CS-27/28/31/33/53 to SP-OP-34								
2E4S02	No work Package assigned this WBS								
2E4S03	No work Package assigned this WBS								
2E4S04	SP-CS-33						c		
2E4S05	No work Package assigned this WBS								
2E4S06	No work Package assigned this WBS								
2E4S07	Completed 1990 SP-CS-62/33 32 to SP-OP-35	Nov-90					c		
HIGHWALL RECLAMATION									
2E5J01	Trim JP Highwalls								
2E5J02	Scale JP Highwalls								
2E5N01	Scale N. Paguate Highwalls	Dec-91							
2E5N02	Trim N. Paguate Highwalls	Dec-91							
2E5S01	Scale S. paguate Highwalls	Dec-91							
2E5S02	Trim S. Paguate Highwalls	Dec-91							
EROSION CONTROL									
2E6N01A	Rio Moquino Erosion Control	Nov-94							
2E6N02	Delete Rio Moquino Channel								
2E6N03	Deleted 1990 Bedding Material								
2E6X01	Deleted 1990 Quarry Rock								
2E6X02	Deleted 1990 Process Rock								
2R1N01	Reseed N P Flat Areas	Nov-94							
2R1N02	Reseed N P Slope Areas	Nov-94							
UNDERGROUND ENTRIES ABANDONMENT									
2S1J01	Seal JP-SS-50 Entries								
2S1J02	Seal JP-PS-46 Entries								
2S1N01	Seal PW-2/3 Adit	Feb-90							
2S1S01	Seal P-13 Adit	Dec-91							
2S1S02	P-10 Decline Closure	Feb-92							
2S1S03	Seal H-1 Adit	Feb-90							
2S1S04	Seal Vent Holes	Feb-92							
2S1S05	Plug Drill Holes	Feb-90							
PIT WATER									
2S2J01	Dewater Jackpile Pit PY-91 92 93	Dec-91							
2S2N01	Dewater No. Paguate Pit	Jul-90							
2S2S01	Dewater So. Paguate Pit	Nov-90							

Used Marvin's Closeout Summary Table and Added entries from Monthly Report "Detail for PTD"		Marvin's Closeout Dates	Coded for Various Pile Categories					ROD Categories	Relate Draft EIS Piles to Work Units
			Proto	Waste	Shale	Topsoil	Contam.		
									EIS Proto, Waste & Topsoil Piles
	SURFACE STRUCTURE DEMOLITION								
2S3J01	Demolish Jackpile Surface Structures								
2S3N01	Demolish No. Paguate Structures	Feb-90							
2S3S01	Demolish South Paguate Surface Structures								
2S4XY	Not Assigned								
	PERMANENT STRUCTURE								
2S5J01	Construct Permanent Access Roads JP								
2S5J02A	Rio Moquino Drop Structure								
2S5J02	Construct Fences-Jackpile Area	Dec-91						1D	
2S5N01	Constr. Permanent Access Roads NP								
2S5N02	Construct Fences-N. paguate Area	Dec-91						1D	
2S5S01	Constr. Permanent Access Roads SP								
2S5S02	Construct Fences-S. paguate Area	Dec-91						1D	
2S5J09	Constr. Perm Fences All Areas								
	SEED BEDS								
2R1J01	Prepare Bed and Seed JP Flat Areas								
2R1J02	Prepared Bed and Seed JP Slope Areas								
2R1N01	Prepare Bed and Seed NP Flat Areas								
2R1N02	Prepared Bed and Seed NP Slope Areas								
2R1S01	Prepare Bed and Seed SP Flat Areas								
2R1S02	Prepared Bed and Seed SP Slope Areas								
2R1S03	Complete 1990 Reseed and Housing Area								
	IRRIGATION								
2R2J01	Deleted 1990 Irrigation								
2R2N01	Deleted 1990 Irrigation								
2R2S01	Tree Planting								
	BENCHES/TERRACING								
2T2J01	JP-WS-01 Slopes	Jul-94							Slope FD-2
2T2J02									
2T2J03	Cut JP-WO-03A /3B/4A/4B Slopes								Slope X,1,Y,Y2
2T2N01	Cut NP-WO-01 Rio Moquino Benches	Sep-92							
2T2S01	Cut SP-SW-06 Slopes Oak Canyon								
2T2PLR	Misc Repairs PY 93 Force Account								
2T1J01	Terracing JP Area 29000 lf								
2T1N01	Terracing NP Area 1200 lf								
2T1S01	Terracing SP Area 19100 lf								

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Activity in Work Units Based on Monthly Reports		Completion Dates	From Monthly Reports		From Monthly Reports C = Closeouts from Section 5.3																																																																							
					MONTHLY REPORTS A=Activity (Section 5.2) C=Field Completion (Section 5.3 Item 2) S=Suspended Activity (Section 5.2)																																																																							
					Month																																																																							
					Year																																																																							
Work Unit Description.		Marvin's Table	Construction Report		Report Number																																																																							
		Completion Dates	Vol.	Completion Date	POL Signature																																																																							
					Certified																																																																							
2E3J19	Haul Shale from JP-WS-15 to D1	NC																																																																										
2E3J20	Haul Shale from JP-WS-15 to D2 Shale Cover	Apr-93																																																																										
2E3J21	Haul Shale from JP-WS-15 to D7	NC																																																																										
2E3J22	Haul Shale from JP-WS-15 to D11	NC																																																																										
2E3J23	Haul Shale from JP-WS-15 to D12	Apr-93																																																																										
2E3J23	Shale JP-D15	Sep-93																																																																										
2E3J24	Haul Shale from JP-WT-02 TO D8A	Nov-94																																																																										
2E3J24	JP-WO-02	NC																																																																										
2E3J25																																																																												
2E3J26	Shale Cover JP-D13	Jul-94																																																																										
2E3J27	Shale JP-D14 or D4	Sep-93																																																																										
2E3J28	Haul Shale from JP-WT-02 to D15	Jul-94																																																																										
2E3J29	Haul Shale from JP-WT-02 to D16	Sep-93																																																																										
North Paguate N=North Paguate																																																																												
2E3N01	Haul Soil from NP-SB-61 to NP-D8	Sep-92																																																																										
2E3N02	Haul Soil from NP-SB-26 to NP-D2	Sep-91	1.0	04-Sep-91	Olsen																																																																							
2E3N02	Soil Cover NP-D7	Sep-92																																																																										
2E3N03	Haul Soil from NP-SB-27 to NP-D7	NC																																																																										
2E3N04	Haul Soil from NP-SB-27 to D9	Feb-92																																																																										
2E3N05	Haul Soil from NP-SB-27 to D6	Dec-92																																																																										
2E3N06	Haul Soil from NP-SB-61 to NP-D9	Feb-92																																																																										
2E3N07 Topsoil	Haul Soil from SP-DN-61 to NP-D4	Nov-91	1.0	13-Nov-91	Olsen																																																																							
2E3N07 Shale	Haul Soil from SP-DN-61 to NP-D4		1.0	16-Dec-91	Olsen																																																																							
2E3N08 Topsoil	Haul Soil from SP-DN-61 to NP-D1	Nov-91	1.0	13-Nov-91	Olsen																																																																							
2E3N08 Shale	Haul Soil from SP-DN-61 to NP-D1		1.0	16-Dec-91	Olsen																																																																							
2E3N09	Haul Soil from SP-DN-61 to NP-D3	Sep-91	1.0	4-Sep-91	Olsen																																																																							
2E3N10	Haul Soil from SP-DN-61 to NP-D5	Sep-91	1.0	4-Sep-91	Olsen																																																																							
2E3N11	Haul Soil from SP-DN-61 to NP-D10	Sep-92																																																																										
2E3N12	Soil to NP-D6 (Benches)	Sep-92																																																																										
2E3N13	Haul Shale Cover From NP-WS-31 to N P-D9	Feb-92																																																																										
2E3N14	Shale Borrow to N P-D4	Sep-91	1.0	9-Apr-91	Olsen																																																																							
2E3N15	Shale Borrow to NP-D5	Sep-91	1.0	4-Sep-91	Olsen																																																																							
2E3N16	Haul Shale from NP-WS-31 to NP-D8	Feb-92																																																																										
2E3N16	Shale Cover NP-D8	Sep-92																																																																										
2E3N17	Haul Shale from NP-WS-31 to NP-D10	Sep-92																																																																										
2E3N18	Haul Shale From NP-WS-03 to NP-D3	Sep-91	1.0	4-Sep-91	Olsen																																																																							
2E3N19	Haul Shale From NP-WS-03 to NP-D3	Sep-91	1.0	14-Sep-91	Olsen																																																																							
2E3N20	No Work Package Assigned this WBS#																																																																											
2E3N21	Haul Shale from NP-WS-03 to NP-D1	NC																																																																										
South Paguate S=South Paguate																																																																												
2E3S01	Topsoil Soil Borrow SP-OP-35 (SP-D1) from SP-SB	Sep-91																																																																										
2E3S02	Topsoil Soil Borrow SP=WS-17(SP-D2) from SP-SB	Dec-91	1.0	16-Dec-91	Olsen																																																																							
2E3S03	Topsoil Soil Borrow to SP-D3 from SP-SB-44	Dec-91	1.0	16-Dec-91	Olsen																																																																							
2E3S04	Haul Soil from SP-SB-42 to SP-D4	Feb-92																																																																										
2E3S05	Haul Soil from SP-SB-42 to SP-D5	Feb-92																																																																										
2E3S06	Haul Soil from SP-SB-42 to SP-D6	Feb-92																																																																										
2E3S07	Haul Soil from SP-SB-42 to SP-D7	Feb-92																																																																										
2E3S08	Topsoil to SP-D8 from SP-SB-44	Dec-91	1.0	16-Dec-91	Olsen																																																																							
2E3S09	Topsoil to SP-D9 from SP-SB-42	Dec-91	1.0	16-Dec-91	Olsen																																																																							
2E3S10	Haul Soil from SP-SB-42 to SP-D10	Not Used																																																																										
2E3S11	Topsoil to SP-D11 from SP-SB-42	Dec-91	1.0	16-Dec-91	Olsen																																																																							
2E3S12	Soil Cover to SP-D12 from SP-SB-43	Feb-92																																																																										
2E3S13	Topsoil to SP-D1B from SP-SB-50	Nov-91	1.0	13-Nov-91	Olsen																																																																							
2E3S14	Shale Cover SP-WO-13A from SP-WS-17	Sep-91																																																																										
2E3S15	Shale Borrow (SP-13B) from SP-WS-15	Not Used																																																																										
2E3S16	Shale Borrow for SP-PS-01 from SP-WS-07	Sep-91	1.0	9-Apr-91	Olsen																																																																							
2E3S17	Shale Cover to SP-14 from SP-WS-07	Dec-91	1.0	16-Dec-91	Olsen																																																																							
2E3S18	Haul Shale Borrow from SP-WS-07 to SP-WO-04	Sep-91	1.0	9-Apr-91	Olsen																																																																							
2E3S19	Haul Shale from Sp-WS-07 to SP-D10	Nov-91	1.0	13-Nov-91	Olsen																																																																							
2E3S20	Haul Shale to SP-38 Shale from SP-WS-07	Sep-91	1.0	4-Sep-91	Olsen																																																																							
2E3S21	Haul Shale Cover from SP-WS-07 to SP- WO-10	Sep-91																																																																										
CONTAMINATED SOIL EXCAVATION																																																																												
Jackpile J = Jackpile																																																																												
2E4J01	Haul JP-CS-36 to JP-OP-41 for Backfill	Feb-92																																																																										
2E4J02	Haul JP-CS-37/38 to JP-OP-41 Backfill	Dec-92																																																																										
2E4J03	No work Package assigned this WBS																																																																											
2E4J04	Combined into 2E4J02																																																																											

APPENDIX B

Photographic Documentation



Photo B-1: Permanent Pond in NP-OP-20 near MW 20 W

OAS Photo August 2006



Photo B-2: North Side of Waste Pile "H"

OAS Photo August 2006



Photo B-3: Waste Pile "J" - Sloped and Seeded

OAS Photo August 2006



Photo B-4: Fencing Photo from Monthly Report No. 14, Figure 3



Photo B-5: SP-OP-34 SW Highwall, Naturally Sloughing

OAS Photo, August 2006



Photo B-6: SP-OP-35 Highwall

OAS Photo August 2006



Photo B-7: Jackpile Highwall along Gavilan Mesa

OAS Photo, August 2006



Photo B-8: Photo from Monthly Report No. 14 Figure 6 Terrace and Berm after unusually large rainfall



Photo B-9: Berm in South Paguate Pit, holding water as designed OAS Photo August 2006



Photo B-10: Additional view of Berms in South Paguate Pit OAS Photo August 2006



Photo B-11: South End of "I" above Road

OAS Photo August 2006



Photo B-12: Blowout in Pile "A" Lower Terrace

OAS Photo August 2006



Photo B-13: Roadway Erosion East Side of Wastepile "I"

OAS Photo August 2006



Photo B14: Location of former protore piles along the Rio Paguate OAS Photo August 2006



Photo B-15: Armored Toe of Pile "T" along the Rio Moquino. POL Archived Photo taken sometime after Armoring was completed (late 1994).



Photo B-16: Armored Toe of Pile "T" along the Rio Moquino, the former road area is almost completely eroded.
OAS Photo August 2007



Photo B-17: Rip Rapped Toe of Pile “N” and “N2” along the Rio Moquino, Close up of Erosion of most of the former roadway.



Photo B-18: Former road crossing of Rio Moquino

OAS Photo August 2006



Photo B-19: End of Headcutting , Area of Exposed Sandstone OAS Photo August 2006



Photo B-20: In the background is Waste Pile "J" which was left in place, the area in front is the east side of "J" and contained the former protore piles "SP-6B and SP-17B C". OAS Photo August 2006



Photo B-21: Blocked Drainage North of FD-1

OAS Photo August 2006



Photo B-22: P-10 Well and Tank.

OAS Photo August 2006



Photo B-23: New Shop Well and Tank.

OAS Photo August 2007

APPENDIX C

**JACKPILE-PAGUATE URANIUM MINE
SITE MAPS (on CD-ROM)**

**EXHIBIT 1 – 2003 AERIAL PHOTOGRAPH – WITH SITE FEATURES OF THE
JACKPILE-PAGUATE URANIUM MINE**

**EXHIBIT 2 – 1995 TOPOGRAPHIC BASE MAP – WITH SITE FEATURES OF
THE JACKPILE-PAGUATE URANIUM MINE**

**Jackpile-Paguate
Uranium Mine
Record of Decision
Compliance Assessment
CD-ROM**



September 2007

**Appendix C
Exhibit 1 & Exhibit 2
Aerial Photo & Topo Map**

**Prepared by: OA Systems Corporation
2201 Civic Circle, Suite 511
Amarillo, Texas 79109**

APPENDIX D

**ANALYSIS AND REVIEW OF:
RE-VEGETATION,
CEDAR CREEK VEGETATION SURVEY,
GAMMA RAD-RADON GAS,
SOILS AND UPTAKE,
WATER QUALITY AND WATER QUALITY ADDENDUM
(Monitoring Results, Water Quality and
Water Quality Addendum also on CD-ROM)**

**JACKPILE-PAGUATE URANIUM MINE
POST-RECLAMATION
RE-VEGETATION SUCCESS ANALYSIS**

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1.0 INTRODUCTION

This report presents a review of post-reclamation vegetation monitoring data and an analysis of vegetation success for the reclaimed Jackpile-Paguate Uranium Mine.

The objectives of this report are to:

1. Determine if the post-reclamation vegetation monitoring has met the requirements of the Jackpile-Paguate Reclamation Project Record of Decision (ROD) (DOI₂, 1986) as defined in the Environmental Impact Statement (DOI₁, 1986)
2. Analyze the vegetation survey data collected to determine if the vegetation parameters met the requirements established in the ROD.
3. Determine if the revegetation on the reclaimed mine is stable and self-sustaining.
4. Make recommendations on how to overcome any ROD deficiencies.

The following provides an overview of the reclamation and revegetation on and around the mine site, previous studies on reclamation, and the basis for making decisions on the mine reclamation status.

2.0 BACKGROUND

The area of the mine and surrounding landscape is a region of broad mesas and plateaus separated by deep canyon, dry washes, and broad alluvial valleys on the southeastern edge Colorado Plateau province. This is a semi-arid region that supports grasslands dominated by blue grama/galleta on the mesas and uplands, and alkali sacaton in the valleys.

This project involved the reclamation of the three open pits, 32 waste dumps, 23 protore (sub-grade ore) stockpiles, four topsoil stockpiles, as well as roads and buildings on the remaining 2,656 acres of disturbed land.

As defined in the ROD, the objectives of the reclamation are:

- 1) To ensure human health and safety.
- 2) To reduce the release of radioactive elements and radionuclei to as low as reasonably achievable.
- 3) To ensure the integrity of all existing cultural, religious and archeological sites.
- 4) To return the vegetative cover to a productive condition compatible with the surrounding area.
- 5) Provide for additional land uses that are compatible with other reclamation objectives and that are desired by the Pueblo of Laguna.
- 6) Eliminate the need for post-reclamation maintenance.
- 7) Blend the visual characteristics of the mine with the surrounding terrain.
- 8) Employ the Pueblo of Laguna people in efforts that afford them opportunities to utilize the skills or train them as appropriate.

In addition, it was also important to determine if the EIS and the ROD requirements are still applicable to the mine site after 20 years because reclamation techniques have improved and the knowledge base has been enhanced. To perform this evaluation, the following reports and surveys were reviewed and analyzed:

1. Jacobs Engineering Group, Inc., *"Jackpile Project, Final Environmental Monitoring Plan"*, 1989.
2. United States Government, Soil Conservation Service-Memorandum, Noel Marsh, Area Range Conservationist, *"Trip report-review current plans, specifications and problems pertaining to revegetation of the Jackpile mine reclamation area"*, March 13, 1990.
3. United States Government, Soil Conservation Service-Memorandum, Allan Ardoin, Area Soil Scientist, *"Trip report-Review of Jack Pile Mine Reclamation by Area Soil Scientist and Area Range Conservationist"*, March 23, 1990.
4. Landmark Reclamation/Weston, *"Jackpile Reclamation Project, Pueblo of Laguna, New Mexico, Soils and Vegetation Evaluation for Final Reclamation"*, Final, April 1991
5. Munk, Lewis P. and Boden, Paul, Soils and Biogeochemistry, *"Interim Reclamation Success Analysis, North and South Paguate Open Pits, Jackpile-Paguate Uranium Mine"*, December 1996.
6. USDA, Natural Resources Conservation Service, National Range and Pasture Handbook-*Inventorizing and Monitoring Grazing Land Resources*, Chapter 4, 1997.
7. USDA, Natural Resources Conservation Service, Paguate-Jackpile Mine 1998 Vegetative Inventory [Production Surveys], 1998
8. USDA, Natural Resources Conservation Service, Vegetation Inventory, Production Surveys, August 16, 2000.
9. USDA, Natural Resources Conservation Service, Vegetation Inventory, Production Surveys, September 7, 2006
10. Cedar Creek Associates, Inc. & S. Lynn Bamberg, LLC, *"2006 Vegetation Monitoring, Jackpile Paguate Reclamation Project"*, November 2006.

Reclamation and revegetation techniques were first tested by the Anaconda Mining Company (AMC) starting in 1976 on a mining waste pile of 50 acres, and continued on 11 additional waste piles in 1977, 1979, and 1980-1981 (Weston, 1991). The techniques AMC tested included the development topsoiling procedures based on soils analysis, seed mixtures, fertilization, and straw mulching. The results of the revegetation testing showed abundant vegetation on some waste piles and poor results on others.

There was no site activity from 1982 to 1989. Final reclamation of the entire mine site started in 1990, and was completed at the end of 1996. The 10-year ROD compliance monitoring requirement for vegetation started in January 1996, and was completed in November 2006.

The basic reclamation techniques used in the final reclamation from 1990-1996 were to fill in the pits with protore and mine wastes, slope and grade areas to be reclaimed, cover

with up to 24 inches of topsoil, fertilize and seed the prepared surfaces. Site stability and erosion was controlled by sloping and armoring waste dumps and pit slopes.

3.0 REQUIREMENTS OF THE ROD AND EIS

Several of the requirements of the ROD and EIS address the revegetation and topsoiling procedures to be followed, the monitoring period, and success criteria for vegetation. Revegetation methods are given in Section 9 of the ROD, and state that:

- Topsoil (Tres Hermanos sandstone) will be placed in the pit bottoms, waste piles, and other areas of the mine,
- Surface preparation using fertilizer, disking, and contour furrowing,
- Seeding and seed mixtures consisting of native plant species compatible with post-mining grazing and local environmental, and
- Plant establishment will be considered successful when revegetated areas reach 90% of the density, frequency, foliar cover, basal cover, and production of undisturbed reference areas (but not sooner than 10 years following seeding).

The monitoring period for vegetation success was therefore established to be 10 years with the frequency and type of monitoring surveys not specified. Table 1-5 in the EIS specifies annual monitoring on pit bottoms, waste dumps, and reference areas for density, frequency, foliar cover, basal cover, and production using a Community Structure Analysis (CSA) method. The proposed monitoring program is presented in Table 3-1.

**Table 3-1
Proposed Vegetation Monitoring Program in the EIS (DOI, 1986)**

Item	Proposed Vegetation Monitoring for Proposed Alternative	
Vegetation success	Stations	Waste dumps, pit bottoms, off-site reference areas
	Parameters	Density, frequency, foliar cover, basal cover, and production
	Frequency	Annually
	Duration	10 years after seeding.

Several interim documents deal with the sampling type and frequency, and success criteria for vegetation. The monitoring plan proposed by Jacobs Engineering (Jacobs 1989), describes a program of vegetation surveys that presents methodology and frequency of sampling that is virtually identical to the ROD and EIS requirements. The Soils and Vegetation Evaluation for Final Reclamation, Jackpile Reclamation Project (Landmark/Weston 1991) suggests a single set of vegetation standards was needed rather than using multiple reference areas, and presents a vegetation ranking system to determine monitoring and successful release for post-mining land uses. The specific criteria are an average of values from literature and surveys on and adjacent to, the Jackpile mine. The monitoring report for interim reclamation success (Munk and Boden, 1996) states that the use of reference areas as a reclamation standard is complicated by the lack of a model reference with ideal site characteristics. The report also states, "*...the reclamation success is obscured by these simple single parameter statistical comparisons*

because of differences in the vegetative composition among the reclaimed and reference areas.”

4.0 VEGETATION PARAMETERS MONITORED AND METHODS

Most of the required vegetation parameters were monitored during the three periods referenced below.

1. In October 1990 (Weston 1991) both reclaimed mine areas and undisturbed reference areas were surveyed for foliar cover, basal cover, frequency, density and production. Vegetative data was collected using line intercept and the quadrat methods at twelve locations on and off the site.
2. In September/October 1996 (Munk and Boden 1996), the reclaimed mine sites were surveyed for vegetation in the North and South Paguate pits and two reference areas for all the required parameters. Plant production was for perennial grasses only, without shrubs or forbs. They monitored a total of 40 plots in three pits, and 30 plots in the two reference areas using a transect/quadrat system.
3. In November 2006 (Cedar Creek, 2006) the North and South Paguate Pits were surveyed for vegetation for foliar cover and plant production using a transect/production plot method. After an initial reconnaissance of the entire pit area, three representative “sites” were selected. At each of the three sites, five cover transects were sampled in a spoke-like manner radiating from the center of the site and five production samples were placed at the end of each transect. In addition, a qualitative rating of six specific parameters (wind erosion, water erosion, soil crust, plant vigor, seedlings, and seed reproduction) was conducted along each transect. The final evaluation at each site was a qualitative assessment of the rangeland health using indicators and rating categories developed by the Natural Resource Conservation Service (NRCS).

In order to determine trends in vegetation progress the NRCS (NRCS 1998, 2000, 2006) sampled the vegetation for plant production at various locations in the pit bottoms. The vegetation was sampled using a clipped quadrat and estimation method to determine pounds per acre of current production.

5.0 RESULTS

The results of the monitoring indicate that the revegetation across the reclaimed mine areas has been successful based on the criteria developed by Landmark/Weston after the monitoring of 1990. After the monitoring of 1990, Landmark/Weston determined that basal area data were inconsistent, and of little comparative value. The performance criteria in the ROD are not applicable to the Jackpile reclaimed lands, since no comparable reference areas are available. The other values of cover, density, and

production varied greatly depending on the year and area surveyed. It was recommended that the specific vegetation ranking criteria be developed based on acceptable values rather than specific reference sites. Using these criteria, the report stated “*All of the reclaimed sites except one (vegetation survey site V-4) could be released for post-reclamation land uses without further monitoring.*” The 1991 report also suggested that monitoring frequency be determined by the ranking based on acceptable vegetation criteria presented in Table 3.6. The NRCS methodology document (NRCS 1997) described trends and rangeland ecological health attributes, but provided no health rating system.

The vegetation ranking criteria proposed in Tables 3.5, 3.6 and 5.6 from the Landmark/Weston 1991 report has been combined for this report and is presented in Table 5-1 below. As proposed in Table 5.6 of the Landmark/Weston 1991 report, and shown in the right hand column in Table 5-1 below, final release of the vegetation requirement could be made if, after 10 years, the composite vegetation ranking was good to excellent and the trend was stable.

Table 5-1
Specific Vegetation Ranking Criteria for Reclaimed Land,
Composite Ranking Value and Monitoring Requirements
(compiled from Tables 3.5, 3.6 and 5.6 – Landmark/Weston 1991)

Specific Vegetation Ranking	Ranking Value	Foliar Cover* (%)	Basal Cover* (%)	Production* (lbs/acre)	No. of Species Present*	Composite Ranking Value	Final Release
Excellent	10	≥ 18.0	≥ 8.0	≥ 1000	4	$X^b \geq 36$	After 10 years
Very good	8	≥ 14.0	≥ 7.0	≥ 750	4	$28 \leq x < 36$	After 10 years, and stable or inclining trend
Good	6	≥ 12.0	≥ 6.0	≥ 650	3	$20 \leq x < 28$	After 10 years, and stable trend
Fair	4	≥ 10.0	≥ 4.0	≥ 450	2	$12 \leq x < 20$	Not allowed
Poor	2	≥ 5.0	≥ 3.0	≥ 250	1	$4 \leq x < 12$	Not allowed
Failure	0	< 5.0	< 3.0	< 250	1	$x < 4$	Not allowed

*Based on desirable species of grass

^bX is equal to the summation of specific ranking values assigned to the four criteria in Table 3.4.

Data from the detailed monitoring reports in 1990 (Landmark/Weston 1991), 1996 (Munk and Boden 1996), 2006 (Cedar Creek 2006) and NRCS (1998, 2000, 2006) show a consistent inclining trend and pattern of good to excellent plant communities and vegetation based on cover, diversity, density, and plant production.

Data from the Landmark/Weston 1991, Munk and Boden 1996, Cedar Creek 2006 and NRCS 1998, 2000, 2006 reports is summarized below in Table 5-2.

Table 5-2
Results of the Vegetation Monitoring, Pit Bottoms

Year	¹ Ref.	Foliar cover %		Basal cover %		³ Diversity #/plot		Density #/m ²		Production lbs/ac	
		Mine	Ref	Mine	Ref	Mine	Ref	Mine	Ref	Mine	Ref
1990	1	48.4	25.3	11.9	9.9	9.2	14.8	30.3	59.5	² 1043	² 1343
1996	2	42.6	50.4	6.4	7.4	10.0	11.0	20.0	38	² 603	² 328
1998	3	-	-	-	-	17.0	12.3	-	-	⁴ 884	⁴ 573
2000	3	-	-	-	-	11.0	-	-	-	⁴ 523	-
2006	3	-	-	-	-	10.0	-	-	-	⁴ 938	-
2006	4	49.4	-	-	-	13.0	-	-	-	⁴ 825	-

¹References: 1-Weston 1991; 2- Munk and Boden 1996; 3- NRCS 1998, 2000, 2006; 4- Cedar Creek 2006

²perennial grasses only, wet weight

³Numbers of species recorded per plot, also called species richness

⁴Total vegetative production, dry weight

Information provided in the 1990, 1996 and 2006 monitoring reports consistently indicated that vegetation on the reclaimed mine areas could be considered successful in meeting the primary goals of landscape stability, productivity, and well established plant communities. According to the cover and productivity, two of the important parameters for determining vegetation trends, the reclaimed mine areas showed good to excellent vegetation from 1990 until late 2006. Frequency (percentage that a plant species occurs in sample plots) was not a good measure of plant success; however, diversity of the reclaimed plots surveyed was as good, or better, than the natural vegetation indicating good vegetation structure. Plant production varied greatly between years measured due to differences in timing and amounts of rainfall. The years from 1999 to 2005 were drought years in this region with poor plant growth.

The 1996 monitoring activities were conducted, and the monitoring report prepared (Munk and Boden 1996), at the end of the active reclamation program during a season of good rainfall. The results of this interim monitoring indicate that, *"In general, reclamation in the pit bottoms can be considered successful in meeting the goals of landscape stability, productivity, and containment of the protore."* (Munk and Boden 1996). The reclaimed areas did not meet the strict numerical standards of the ROD requirements, but had vigorous and productive plant communities with desirable perennial grasses and shrubs. There were less desirable annual grasses in the reference areas due to past grazing and land use practices.

Monitoring activities in the 2006 monitoring report (Cedar Creek 2006), in addition to assessing cover and productivity, followed suggested protocol based on NRCS methods for evaluating and rating ecological sites for health and stability in Chapter 4 of the National Range and Pasture Handbook for inventorying and monitoring land resources. The sampling and monitoring results compared these naturalized plant communities (on the reclaimed mine site) to the desired plant community based on the reclamation and revegetation techniques (grading, topographic and water control, and seed mix) used on the Jackpile mine. The trends and ecological health of the plant communities, and other physical attributes, showed excellent balance and sustainability of the reclaimed areas for

physical structure (topography, soils), hydrology (streams, runoff, watersheds, pools, springs and seeps), and ecology (vegetation, animals, and habitats).

In summary, plant productivity surveys conducted by NRCS (NRCS 1998, 2000, and 2006) confirmed the stability and trend in the vegetation on reclaimed areas. Productivity of the vegetation was consistent and was influenced by the local weather patterns. For example, productivity was lower in the drought year of 2000, but had recovered and was very productive in 2006. The summer and fall of 2006 had abundant and well-spaced rains and the vegetation responded with good productivity. Perennial grasses were tall and produced abundant seed. Vegetation and surface stability was observed in early fall after a record amount of rainfall during the "monsoon" season in mid to late summer. There was excellent growth and productivity of the vegetation due to the abundant soil moisture. There was a diversity of desirable perennial grasses, shrubs, and forbs in the pits, side slopes, and level areas that formed stable vegetation communities. Some minor surface gullies formed, which were repaired, and had started revegetating naturally from the abundant seed bank in the soils. Some low depressions in the filled mine pits still had standing water from runoff,

6.0 DISCUSSION OF RESULTS

The results of the vegetation monitoring show good to excellent plant communities with total foliar cover values of 43-50%; according to Landmark/Weston (1991) regional values are 10.3% to 26.5%, so the cover values far exceed the 90% specified in the ROD; and plant production of 523-1043 lbs/ac on the reclaimed areas. The trends in vegetation are stable for plant diversity and health. The reclaimed mine areas can be considered successfully revegetated based on the available monitoring data. The reclaimed mine has a stable and self-sustaining diverse ecosystems with very good to excellent vegetative cover and productivity of desirable plant species, and good habitat for local wildlife. There are no comparable reference sites for determining the success standards of these ecosystems as required by the ROD. However, not meeting the ROD requirements is acceptable because there are no suitable or comparable reference sites available. It should be noted, however, that the ROD has been more than adequately met. The recommendations of the monitoring reports and this summary are that the mine has successful vegetation based on plant cover, production and other criteria of stability and sustainability.

The reclaimed mine can be released from the 10-year monitoring period based on revegetation success. Post-reclamation land uses can be instituted based on future management decisions. These land uses were listed in the ROD as grazing, light manufacturing, office space, mining, and major equipment storage. There was concern expressed by allowing livestock grazing in the pit bottoms because of potential uptake of metals and radionuclides. This is discussed in the plant uptake evaluation (OA Systems Corporation, *Jackpile-Paguate Uranium Mine Record of Decision Compliance Assessment*, Appendix A, 2007).

6.1 Data Condition

The available data from the vegetation surveys were evaluated for applicability to the revegetation monitoring. The sampling periods were adjusted based on vegetative growth and drought years. An evaluation of the concurrent and post reclamation vegetation monitoring data is presented in Table 6-1. The lack of vegetation monitoring during the period of 2000 until fall of 2006 was the most significant problem.

Table 6-1
Evaluation of Concurrent and Post Reclamation Vegetation Monitoring Data

Positives	Negatives
<ul style="list-style-type: none">• Reports were clear and concise.• Survey methods were adequately explained.• Reports were consistent for vegetation success• Protocol for determining ecological health and stability were positive.• Overall, vegetation was good to excellent over the entire mine site.• Procedures for reestablishing vegetation were followed and produced good results.	<ul style="list-style-type: none">• Not all vegetation parameters were measured during each period.• Methods were not standardized for yearly comparisons.• Vegetative trends were inferred from incomplete surveys.• Several years from 1996 to 2006 had no data or surveys.• Not all parameters suggested by the Environmental Monitoring program were analyzed for each year

6.2 Vegetation Conditions

Overall, revegetation in the pit bottoms and slopes that were sampled was excellent and especially robust in the above-average precipitation year 2006. The blue grama seed heads were nearly hip high, and other grasses were tall and produced an excellent seed crop. Plant diversity within the revegetation was better than expected given the seed mixtures used or 7-9 species, however 72 plant species (Munk and Boden, 1996) were noted in the reclaimed areas mostly from natural seed dispersal processes. With the exception of low forb species and lack of biological crusts, all the rangeland health indicators were rated as having little or no departure from the ecological site descriptions. With respect to the key qualitative parameters, all were rated in the highest or next-to highest category except for soil crusts (Cedar Creek 2006). Soil crusts are more common with longer soil development.

The reclaimed vegetation is a grassland/shrub community dominated by native grass species, and a sub-component of shrubs. Grasses are dominant in most areas followed by forbs and shrubs. The pit bottoms had two types of vegetation: 1) drier sites in these areas had dominant taxa of blue grama (*Bouteloua gracilis*), side-oats grama (*Bouteloua curtipendula*), four-wing saltbush (*Atriplex canescens*), and alkali sacaton (*Sporobolus airoides*) with 27.1%, 12.7%, 9.1%, and 3.5% cover, respectively; and 2) in moist areas the dominant taxa were alkali sacaton, four-wing saltbush, galleta (*Hilaria jamesii*), and

blue grama with 22.5%, 3.8%, 2.2%, and 1.5% cover, respectively. Slopes and tops of reclaimed areas have different dominant species in addition to blue grama and galleta with side-oats grama, Indian ricegrass, and yellow sweet clover dominant in some areas. Vegetation on reclaimed sites is diverse, vigorous, and well established.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Based on this vegetation review, the following conclusions can be drawn:

1. The Jackpile Reclamation Project post reclamation vegetation monitoring program deviated from the requirement of the Record of Decision. This was due to modifications in determining vegetative success that was the result of a prolonged drought, as documented in local reports. The monitoring met the intent of the ROD in determining vegetation success, in that the mine was very successfully revegetated based on important vegetation parameters of cover and productivity. The revegetation results did not meet the strict numerical standards of the ROD, but there were vigorous and productive plant communities with desirable perennial grasses and shrubs throughout.
2. As presented in Table 5-1, and discussed in Section 6.2, the condition of post-reclamation vegetation is very good to excellent, and the reclaimed mine has stable and self-sustaining diverse ecosystems, and good habitat for local wildlife.
3. Trends in vegetation are stable for plant diversity and health.
4. The reclaimed mine can be released from the 10-year monitoring period based on revegetation success.
5. Some minor surface gullies formed from record rainfall in 2006 that were repaired and revegetated naturally from the abundant seed bank in the soils.
6. There are no hazards to human health and safety from the current vegetation conditions on the reclaimed mine. The potential for hazards to livestock is discussed in the plant uptake evaluation (OA Systems Corporation, *Jackpile-Paguate Uranium Mine Record of Decision Compliance Assessment*, Appendix A, 2007).

Based on these conclusions, the following recommendations can be made:

1. Vegetation on the reclaimed mine is currently stable and successful.
2. The 10-year monitoring period appears to be sufficient to assess the revegetation and future formal monitoring does not appear to be warranted.
3. Management practices should consider the entire mine site as a resource unit and develop a future management plan along with other units on the Pueblo of Laguna. Future access, roads, and fences should be designed for the management unit.
4. Surface water management plans may need to review the surface runoff options for controlling rills and erosion as it relates to vegetation. Water is concentrated off the faces of the reclaimed waste dumps into long contours that need to be reduced in length. Runoff and water drainage on the reclaimed surfaces should be

allowed to develop channels that will not need to be managed or repaired in the future.

5. Ponds and wetlands are developing in some of the depressions of the mine pits, and are a desirable and productive type ecosystem that should be retained.

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1

2006 Vegetation Monitoring
Jackpile Paguete Reclamation Project
Cedar Creek Associates,
November 2006

1.0 Introduction

The Jackpile Paguete reclaimed mine was monitored for vegetation success during November 2006 for the 10-year monitoring requirement according to the Record of Decision (ROD 1986). This vegetation monitoring event was conducted by Cedar Creek Associates, Inc. using standard and up-to-date methodology.

The two pits in the South Pit area (SP-34 and SP-35) and the one pit in the North Pit area (NP-20) were sampled. The Jackpile Pit was sampled in September 2006 for production by NRCS. Three sites within each pit were selected for sampling. The SP-35 pit had developed three fairly distinct communities and one sampling site was placed in each of these. The SP-34 pit was fairly homogeneous (besides the ponds / wet areas) and the sites were equidistantly placed. The NP-20 pit exhibited two communities / soil types, and two sites were located in the larger galleta community while one was placed in the smaller rockier soil area. At each site, five representative cover transects and production quadrats were placed in the area. The six specific parameter were rated at each cover transect and then the 18 NRCS rangeland health indicators were estimated for the entire site area.

All the specific parameter ratings, NRCS ratings, cover data summary, production data summary, and notes for each site were organized onto Excel worksheets (Jackpile Qualitative, which are available on a CD upon request.). Other summary cover tables and charts, as well as raw data tables are on two files (Jackpile Cover and Jackpile Prod, available on CD). Landscape and ground photographs of each sample site, as well as overview shots of the pits are provided individually and in a four-per-page presentation format (also available on CD upon request). A map of each of the pits with sample site locations and miscellaneous notes are provided in a JPEG format. The following presents the methodology for the cover and production portions of this evaluation as well as a brief synopsis of each pit area.

Overall, the revegetation effort in the pit bottoms that were sampled was excellent and especially robust in this above-average precipitation year. It was difficult to find any major faults with the

reclamation effort, except that plant diversity within the revegetation was lower than expected given the seed mixes used. With the exception of low forb diversity and lack of biological crusts, all the rangeland health indicators were rated as excellent and having little or no departure from the ecological site descriptions. With respect to the key qualitative parameters, all were rated in the highest or next-to highest category except for soil crusts.

2.0 Methodology for Quantitative and Qualitative Vegetation Sampling

2.1 Sample Site Selection and Evaluations

The sample layout protocol for revegetation evaluations in 2006 largely followed procedures developed by Cedar Creek Associates, Inc. to provide representative and cost-effective data for evaluation of revegetation. After an initial reconnaissance of the entire pit area, three representative “sites” were selected (see Maps 1-3). Placement of these sites took into account factors such as dominant vegetation, topography, distance from other sites, and different seed mixes and/or years. At each site, five cover transects were sampled in a spoke-like manner radiating from the center of the site and five production samples were placed at the end of each transect (Note: Figure 1 shows the production quadrat at the beginning of each transect). In addition, a qualitative rating of six specific parameters (wind erosion, water erosion, soil crust, plant vigor, seedlings, and seed reproduction) was conducted along each transect. The final evaluation at each site involved a qualitative assessment of the rangeland health using indicators and rating categories developed by the National Resources Conservation Service (NRCS).

2.2 Determination of Ground Cover

Ground cover at each sample point was determined utilizing the point-intercept methodology as illustrated on Figure 1. As indicated on this figure, Cedar Creek utilizes new state-of-the-art instrumentation it has pioneered to facilitate much more rapid and accurate collection of data. A transect of 10 meters length was extended in the direction of the next sampling location from the flagged center of each systematically located sample point. At each one-meter interval along the transect, a “laser point bar” was situated parallel to, and approximately 4.5 to 5.0 feet vertically above the ground surface. A set of 10 readings was recorded as to hits on vegetation (by species), litter, rock (>2mm), or bare soil. Hits were determined at each meter interval by activating a battery of 10 low-energy specialized lasers^{**} situated along the bar at 10 centimeter intervals and

^{**} Lasers utilized for this instrument are state-of-the-art and are a specialized design to emit a unique electro-magnetic wavelength visible under full sunlight, a condition previously not possible with portable low-energy lasers.

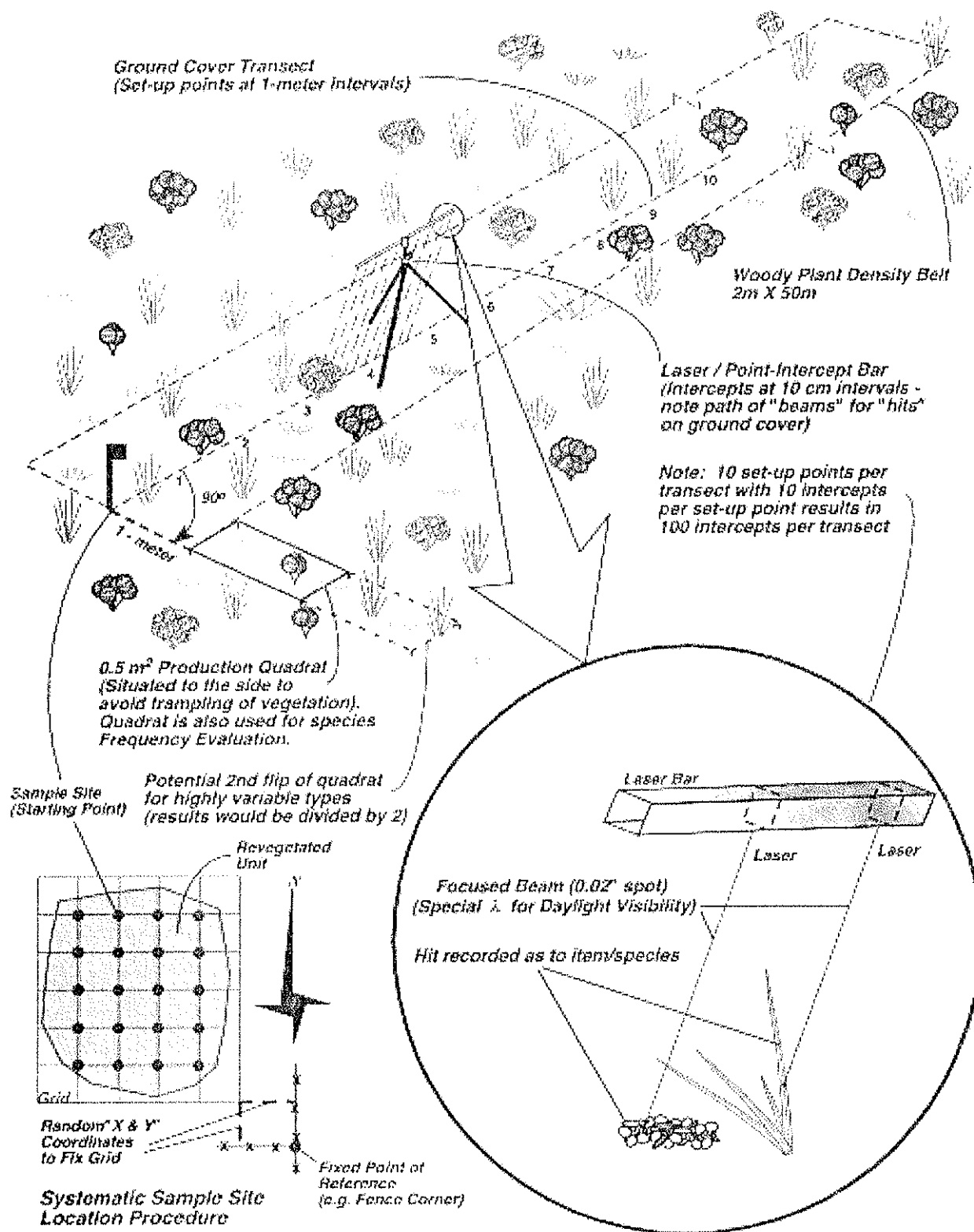


Figure 1
Sampling Procedure at a Systematic Sample Site Location

recording the variable intercepted by each of the narrowly focused (0.02") beams (see Figure 1). In this manner, a total of 100 intercepts per transect were recorded resulting in 1 percent cover per intercept. This methodology and instrumentation facilitates the collection of the most unbiased, repeatable, and precise ground cover data possible.

2.3 Determination of Current Annual Production

At the end of each cover transect, current annual production was collected from a $\frac{1}{2}$ m² quadrat frame placed one meter and 90° to the right (clockwise) of the ground cover transect to facilitate avoidance of vegetation trampled by investigators during sample site location (see Figure 1). From within each quadrat, all above ground current annual vegetation within the vertical boundaries of the frame were clipped and bagged separately by life form as follows:

Perennial Grass	Perennial Forb
Annual Grass	Annual Forb
Shrub	Sub-shrub

In addition, the percentage of warm-season grasses that made up the perennial grass total was estimated to the nearest 5%. All production samples were weighed in the field (wet weights) and then returned to the lab for drying and weighing. Samples were air-dried until a stable weight was achieved (7 days). Samples were then re-weighed to the nearest 0.1 gram.

2.4 Sample Adequacy Determination

Fifteen cover samples within each pit area were collected (five from each site). From these preliminary efforts, sample means and standard deviations for total non-overlapping vegetation ground cover were calculated. For non-monitoring applications, the typical procedure is that sampling continues until an adequate sample, **n_{min}**, has been collected in accordance with the Cochran formula (below) for determining sample adequacy, whereby the population is estimated to within 10% of the true mean (μ) with 90% confidence.

When the inequality (**n_{min}** ≤ **n**) is true, sampling is deemed adequate; and **n_{min}** is determined as follows:

$$n_{\min} = (t^2 s^2) / (0.1 \bar{X})^2$$

where: n = the number of actual samples collected (initial size = 15 or 20)

t = the value from the two-tailed t distribution for 90% confidence with $n-1$ degrees of freedom;

s^2 = the variance of the estimate as calculated from the initial samples;

\bar{x} = the mean of the estimate as calculated from the initial samples.

If the initial samples do not provide a suitable estimate of the mean (i.e., the inequality is false), additional samples would be collected until the inequality ($\bar{x}_{min} \leq \bar{x}$) becomes true. However, because sampling is for managerial (monitoring) information, adequacy is not necessary and is calculated for informational purposes only.

2.5 NRCS Rangeland Health

This suggested protocol is based on NRCS methods for evaluating and rating ecological sites for health and stability as given in Chapter 4 of the National Range and Pasture Handbook for inventorying and monitoring land resources. Sampling and monitoring results will be used to compare these naturalized plant communities (on the reclaimed mine site) to the desired plant community based on the reclamation and revegetation techniques (grading, topographic and water control, and seed mix) used on the Jackpile mine. Trends and ecological health of the plant communities and other physical attributes will be used to determine balance and sustainability of the reclaimed areas. The NRCS also mentions history (when reclaimed) and yearly or other monitoring results to determine trends

The characterization of the reclaimed site has three basic parameters:

Physical structure - topography, soils

Hydrology - streams, runoff, watersheds, pools, springs and seeps

Ecology – vegetation, animals, and habitats.

To determine ecological health and stability, NRCS uses the following attributes

1. Rills
2. Gullies
3. Water flow patterns, channels, streams
4. Wind erosion
5. Bare soil
6. Soil pedestals

7. Soil surface features
8. Cryptobiotic crusts
9. Water infiltration and runoff
10. Plant species composition
11. Functional plant groups – life forms, seasonality, layering
12. Annual productivity and total biomass
13. Plant vigor
14. Recruitment, reproduction, seed production, seedlings
15. Plant mortality
16. Plant stress
17. Litter and plant residues
18. Invasive species (exotics, aliens, “weeds”, noxious)

In addition to ground cover and annual production, the following parameters can be measured or estimated using a plotless technique:

plant species composition to determine functional groups and layering (list all plant species observed in the area.

-

wind and water erosion (on a scale: 1=severe, to 5=none)

soil crusts (scale: 1=none, 5=good microbiotic crust)

plant vigor/stress (scale: 1=stressed, some mortality, to 5=vigorous)

seed or propagules production, seedlings (scale 1=none, to 5=excellent seeds/reproduction)

3.0 Results of the Monitoring

Overall, the revegetation effort in the pit bottoms that were sampled was excellent and especially robust in this above-average precipitation year (the blue grama seedheads were nearly hip high). It was difficult to find any major faults with the reclamation effort besides the obvious high water table/ponding issues and lack of any biological crusts. During these late fall surveys the plant diversity within the revegetation was low and forbs were not observed. Grass diversity decreased

as the water table neared the surface (the wetter and more alkaline locations). Nearly all soil surfaces in the pit exhibited varying degrees of “plate” formation which is typically associated with drying mudflats. It appears that nearly all of these pit bottoms experienced standing water for some period of time this past monsoon season. Most vegetation seems to have withstood this inundation and benefited, but some saltbush and snakeweed may have died. It was difficult to tell whether many of these plants were decadent, senescent or dead. This was especially hard at sample site #2 in the SP-35 pit.

South Pit – SP-34

The SP-34 Pit was sampled with 15 transects in 2006 and is exhibiting excellent revegetation. Perusal of Table 3.1 indicates that the total cover in this area was 58.1% with an average perennial cover of 57.5%. Dominant taxa in this area were blue grama (*Bouteloua gracilis*), side-oats grama (*Bouteloua curtipendula*), four-wing saltbush (*Atriplex canescens*), and alkali sacaton (*Sporobolus airoides*) with 27.1%, 12.7%, 9.1%, and 3.5% cover, respectively. Air-dry production averaged 923 pounds per acre with warm-season grasses averaging 723 pounds per acre and shrubs averaging 194 pounds per acre. The three sample sites were very similar with respect to cover and production with only slight variations in plant composition, bare ground and litter values. With the exception of low forb diversity and lack of biological crusts, all the rangeland health indicators were rated as having little or no departure from the ecological site descriptions. With respect to the key qualitative parameters, all were rated in the highest or next-to highest category except for soil crusts.

Table 3-1. Results of the Vegetation Monitoring at the Jackpile Mine. November 2006			
Plant Canopy Cover - %			
	South Pit – SP-34	South Pit – SP35	North Pit – OP20
Total Plant Cover	58.13	34.33	55.67
Rock	1.27	0.07	3.80
Litter	12.93	17.13	13.47

Bare ground	27.67	49.47	27.07
Plant Production – lbs/acre (air dry)			
	South Pit – SP-34	South Pit – SP35	North Pit – OP20
Perennial Grass	722.78	466.07	783.81
Annual Forbs	12.14	7.61	28.84
Subshrubs	0.00	0.00	65.05
Shrubs	193.74	77.68	122.95
TOTALS	923	551	1002

South Pit – SP-35

The SP-35 Pit was sampled with 15 transects in 2006 and is exhibiting very good revegetation. Perusal of Table 11 indicates that the total cover in this area was 34.3% with an average perennial cover of 33.3%. Dominant taxa in this area were alkali sacaton, four-wing saltbush, galleta (*Hilaria jamesii*), and blue grama with 22.5%, 3.8%, 2.2%, and 1.5% cover, respectively. Air-dry production averaged 551 pounds per acre with warm-season grasses averaging 466 pounds per acre and shrubs averaging 77 pounds per acre. Three vegetation communities were apparent within the pit bottom with transitional ecotypes between each one (see Map 2). Along the eastern edge of the pit, deposition from the reclaimed slopes has produced a slightly sloped narrow strip of land where many of the more xeric seeded species are prevalent. This is the only site in this evaluation where any soil movement was observed. The second site within this pit was located in the central portion where four-wing saltbush and alkali sacaton dominate. This area is wetter and lacking in any grama species. As noted earlier, four-wing saltbush and snakeweed are mainly decadent and/or dead here, perhaps from too much standing water or for too long. The third community and site is located in a seasonally wet meadow that is dominated almost entirely by alkali sacaton. Cover and production values are lowest at this site. Rangeland health and key qualitative parameters are overwhelmingly positive at these three sites with a few exceptions (see Tables 4-6 for details).

North Pit – NP-20

The NP-20 Pit was sampled with 15 transects in 2006 and is exhibiting excellent revegetation. Perusal of Table 12 indicates that the total cover in this area was 55.7% with an average perennial cover of 51.5%. Dominant taxa in this area were galleta, snakeweed (*Gutierrezia sarothrae*), side-oats grama, yellow sweetclover (*Melilotus officinalis*), blue grama, and four-wing saltbush with 30.9%, 5.7%, 4.7%, 4.0%, 3.9%, and 3.3% cover, respectively. Air-dry production averaged 1,002 pounds per acre with warm-season grasses averaging 783 pounds per acre, sub-shrubs 65 pounds, and shrubs averaging 123 pounds per acre. The first two sample sites were very similar with respect to cover and production with only slight variations in plant composition, bare ground and litter values. Sample site #3 was located in the eastern third of the pit and apparently received a different growth medium than the rest of the pit. It appears that native topsoil was used due to the quantity and diversity of native taxa observed. In addition, the soil was rockier and little to no “shrink-swell” plates were noted (possibly due to elevated organic matter typical of topsoils). With the exception of low plant diversity, lack of seedlings, and no biological crusts, all the rangeland health indicators were rated as having little or no departure from the ecological site descriptions. With respect to the key qualitative parameters, all were rated in the highest or next-to highest category except for soil crusts.

4-0 Summary

Plant communities surveyed in the pit bottoms were vigorous and well established, and the rangeland health indicators were rated as having little or no departure from the ecological site descriptions. Plant cover and productivity in this year of abundant rain were high at 34 to 58% cover, and 551 to 1002 lbs per acre.

**POST-RECLAMATION
GAMMA RADIATION AND RADON GAS ANALYSIS
JACKPILE-PAGUATE URANIUM MINE**

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1.0 INTRODUCTION

This report presents an evaluation of gamma radiation and radon gas surveys conducted for the reclaimed Jackpile-Paguate Uranium Mine.

The objectives of this report are to:

1. Determine if the post-reclamation monitoring for gamma radiation and radon gas monitoring met the requirements in the Jackpile-Paguate Reclamation Project Record of Decision (ROD) (DOI, 1986) as defined in Table I-5 of the Environmental Impact Statement (EIS) (DOI, 1986)
2. Review the survey reports and concentrations measured for compliance with the requirements of the ROD.
3. Make recommendations for future monitoring programs and management practices to ensure that the current reclamation status poses no hazards to the environment or human health.

The following presents an overview of the survey procedures, the results of monitoring of gamma radiation and radon gas, and the basis for making decisions on the mine reclamation and future land use status.

2.0 BACKGROUND

The EIS presented several reclamation activities and proposed treatments that were designed to reduce the potential for release and exposure to gamma radiation and radon gas. The activities and treatments were carried out during active reclamation and included:

1. Moving stockpiled protore (Jackpile Sandstone) into the pits and covering with overburden (Mancos Shale) and topsoil (Tres Hermanos Sandstone) before revegetation.
2. Covering exposed surfaces of Jackpile Sandstone on waste dumps with shale overburden and topsoil.
3. Clearing and moving contaminated materials from facilities, roads, rail spur, and disturbed sites; and topsoiling all disturbed sites (old roads, etc.) before reclamation.
4. Stabilizing waste dumps at 3:1 slopes, moving some dumps from drainages, and reducing pit highwalls.
5. Pits were to remain as closed basins and fenced to prevent access of domestic cattle and human entry.

This evaluation used the following reports and monitoring results:

1. Jacobs Engineering Group, *Jackpile Project Environmental Monitoring Plan*, Final, 1989.
2. U.S. Department of the Interior (DOI), *Final Jackpile-Paguate – Uranium Mine Reclamation Project Environmental Impact Statement, Vol. 1*, 1986.

3. U.S. Department of the Interior (DOI), Bureau of Land Management, Memorandum to Bureau of Indian Affairs (BIA), *Subject: Radiological Monitoring, Jackpile Reclamation Project*, May 20, 1994.
4. Pueblo of Laguna, Reclamation Project Manager, "*Jackpile Reclamation Project, Pueblo of Laguna, New Mexico*", Annual Report, 1996
5. Gamma and radon measurements in data sheets (Excel or PDF) for field surveys 1990 to 1996

Monitoring for gamma radiation and radon gas started with active reclamation activities in 1990 and continued until 1997 at the completion of reclamation.

3.0 REQUIREMENTS OF THE ROD AND EIS

Requirements of the ROD and EIS for monitoring gamma radiation and radon gas were specified in Table 1-5 in the EIS. The proposed monitoring program is presented as Table 3-1 below.

**Table 3-1
Proposed Gamma Radiation and Radon Gas
Monitoring Program in the EIS (DOI, 1986)**

Item		
Gamma Radiation	Stations	Each waste dump and selected reclaimed areas
	Frequency	As needed
	Parameters	Ground survey plus final aerial survey
	Duration	Before seeding and once after reclamation is complete.
Radon Gas	Stations	5
	Frequency	Monthly
	Parameters	Rn-222 (pCi/L)
	Duration	A minimum of 3 years following reclamation.

The specified limit for gamma radiation levels following reclamation was twice the background level of 14 micro Roentgens per hour (14 μ R/hr). The specified limit for radon gas levels after reclamation was 3 picocuries per liter (pCi/L) above background of 0.5 for a total of 3.5 pCi/L.

One document addressed the proposed monitoring program after final reclamation was complete. That document, the gamma radiation monitoring plan proposed by Jacobs Engineering (Jacobs 1989), suggested modifications of the requirements of the EIS as follows:

1. Aerial survey should be replaced by an extensive ground survey at 3 feet above ground because it is more accurate and less expensive.
2. All waste dumps with exposed Jackpile Sandstone (protore) or construction areas should be surveyed in a grid pattern prior to placement of shale and topsoil cover.
3. After initial excavation of construction areas or placement of topsoil, the area should be surveyed to determine areas that were twice the background level.

Radon gas surveys were to be modified as follows:

1. Radon was to be continuously monitored during construction at 15 locations on, and around the mine.
2. Radon was to be continuously monitored at 10 locations on and adjacent to the mine for four successive quarters after construction was complete.
3. Monitoring of radon flux was eliminated due to technical infeasibility, and because there was no standard for radon flux.

4.0 PARAMETERS MONITORED AND SAMPLING METHODS

Gamma radiation was measured using a TMA/Eberline gamma meter held three feet above the ground. The gamma surveys started during construction in 1990, and were concluded in 1993. There are no records of gamma radiation surveys after 1993. The following are the areas surveyed during the period of 1991 to 1993. They were selected based on recommendations from the EIS and monitoring reports.

1. Shops, construction buildings, and offices; housing area; Paguate townsite
2. Waste dumps and protore stockpile areas
3. Crusher areas; haul and access roads
4. Loading dock and rail spur from Quirk Station north to the project boundary (in 1990)
5. Three pits (North Paguate, South Paguate, and Jackpile) during backfilling and covering with shale and topsoil

Gamma radiation was measured using grids (100x100 feet or 200x100 feet) and recorded on field sheets, log and summary analytical sheets, and hand-drawn field maps. Measurements are recorded in micro Roentgens per hour ($\mu\text{R/hr}$).

Radon-222 gas was measured using Track Etch[®] cups (Barringer Alpha Track Detectors) at 15 predetermined locations on, and around, the mine as suggested by the monitoring report (Jacobs 1989). The cups were set up on posts three feet above ground at each location, and collected quarterly from April 1990 to May 1997. The monitoring station locations and time were recorded on Radon Test Detector log sheets or field forms, and the results listed on Radon Measurement Data sheets and Monitoring Reports for each quarterly testing period. The complete radon-222 survey results were tabulated and reported in the 1996 Annual Report for the Jackpile Reclamation Project. Measurements are reported in picocuries per liter (pCi/L).

5.0 RESULTS

Gamma Radiation: The results of the gamma surveys showed that open uncovered pits, protore (Jackpile Sandstone) stockpiles, and areas contaminated with ore (i.e., crusher areas, haul roads, etc.) averaged 62 to 173 $\mu\text{R/hr}$ before reclamation activities. Waste dumps measurements varied depending on the surface materials from 19 to 48 $\mu\text{R/hr}$.

Shops and buildings on site initially measured 0.9 to 52 $\mu\text{R/hr}$ in 1991/1992, but were cleaned and reduced to 0.9 to 14 $\mu\text{R/hr}$ in 1993.

During construction and reclamation activities, protore and contaminated areas were removed and placed in pits, which were then covered with shale and topsoil. Measurements of gamma radiation levels on the shale cover in pits and on waste dumps were reduced to 14 to 28 $\mu\text{R/hr}$, and after topsoil placement the readings were reduced further to less than 10 $\mu\text{R/hr}$. Covering the protore and pits with shale and topsoil reduced gamma radiation to acceptable levels. There were no gamma surveys after 1993 when the pits were covered and reclaimed.

Radon Gas: The results of the radon gas surveys were summarized in a table in the 1996 Annual Report, a portion of which is abstracted and presented in Table 5-1 below. The averages of radon gas were all less than 2 pCi/L, and the average for all sites was 1.0 pCi/L. There was no measurement of radon gas above 2.9 pCi/L, which was measured in the Old Shop in 1990. It was subsequently cleaned to reduce radiation. Radon gas was monitored for four quarters after reclamation was completed, in May 1997. None of the radon gas measurements exceeded the limit of 3.5 pCi/L.

Table 5-1
Averages of Radon Gas Measurements in pCi/L at 15 Site Locations
Jackpile Reclamation Project, April 1990 to May 1997

Location	Range	Average
P-10 area	0.4-2.1	0.7
N. Paguate	0.6-<2.0	1.0
OP-19	0.1-<2.0	0.8
Geo Bldg	0.7-1.9	1.2
HIWAY	0.7-2.0	1.2
New Shop	0.4-<2.0	0.6
W. Paguate	0.3-<2.0	0.9
Well-6	0.3-1.8	1.2
Paguate #1	0.3-1.2	0.7
Paguate #2	0.3-2.2	0.5
N. Jackpile	0.3-1.4	0.7
Old Shop	1.1-2.5	1.5
W. Jackpile	0.4-2.9	1.8
SW House	0.4-1.5	0.8
RMG-2	0.1-1.7	0.2

Average (all measurements) 1.0 pCi/L. Standard for the site is 3.5 pCi/L (3 pCi/L above background of 0.5 pCi/L)

6.0 DISCUSSION OF RESULTS

Gamma radiation on the mine reclamation areas was reduced by moving protore and surfaces of the contaminated areas into the pits and covering them with shale and topsoil. Waste dumps that had Jackpile Sandstone on the surface were also covered with topsoil.

These activities effectively reduced measured gamma radiation to acceptable levels of less than 28 $\mu\text{R/hr}$ on the mine areas up to, and during, 1993. There were no records of post-reclamation monitoring of gamma radiation after completion of reclamation in 1996.

All radon gas measurements were consistently below the standard limit of 3.5 pCi/L set by the ROD.

6.1 Data Condition

An evaluation of the gamma radiation and radon gas monitoring data is presented in Table 6-1.

**Table 6-1
Evaluation of Gamma Radiation and Radon Gas Monitoring Data**

Positives	Negatives
Gamma Radiation	
<ul style="list-style-type: none">• Most of the sites selected and measured were at the appropriate locations.• The sample grids adequately covered the sites sampled.• Using hand-held gamma meters was an excellent method for sampling areas.	<ul style="list-style-type: none">• Recommendations for time periods to sample gamma radiation were not followed. There was no post-reclamation monitoring.• Data was not summarized or presented in a form for analysis of results• Data collected was not analyzed for patterns to determine when or where to monitor.• Data was not in a well tabulated form and not checked for accuracy.
Radon Gas	
<ul style="list-style-type: none">• Sampling periods and locations were adequate and followed the recommendations for monitoring and the EIS.• Data was well recorded and summarized in tables.• Data was easily analyzed for meeting standards.	<ul style="list-style-type: none">• None

6.2 Data Evaluation

The gamma radiation surveys were difficult to interpret, and in some instances incomplete. The survey data could have also been plotted on maps or in tables for analysis of patterns or trends.

In contrast, the radon gas measurements were mostly complete, summarized in tables, and easily interpreted in order to analyze for patterns and trends.

The Memorandum (dated May 20, 1994) from the BLM for a review of radiological monitoring stated that; 1) all reclamation personnel have received minimal dosages based on TLD badges, 2) results of the Track Etch[®] canisters for measuring radon are averaging 1.0 pCi/L, and 3) the gamma radiation in the revegetated North and South Paguate pit areas is equal to or less than background, and the gamma readings in backfilled and covered areas of the Jackpile pit are within the required reclamation limit of twice background.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Based on this radiological measurement review, the following conclusions can be drawn:

1. The Jackpile Reclamation Project gamma radiation monitoring program deviated from the requirement of the Record of Decision in that results were not tabulated or analyzed, and were not continued for the specified time periods.
2. Gamma radiation levels are probably below the 28 μ R/hr limit on most areas of the reclaimed mine site, but there is uncertainty due to the lack of recommended post-reclamation monitoring.
3. Radon gas levels were consistently below the limit of 3.5 pCi/L at all locations measured.

Based on these conclusions, the following recommendations can be made:

1. Gamma radiation levels should be checked in specific locations at least one more time to verify that reclaimed areas are meeting the standard of 28 μ R/hr.
2. The reclaimed mine can be released from any requirement for radon gas measurements, and should present no hazards for human health.
3. Post-reclamation land uses can be instituted based on this radiation data evaluation.

8.0. REFERENCES

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**JACKPILE-PAGUATE URANIUM MINE
POST-RECLAMATION
SOILS ANALYSIS AND HEAVY METAL AND
RADIONUCLIDE UPTAKE IN VEGETATION ANALYSIS**

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1.0 INTRODUCTION

This report presents a soil evaluation and data review for the reclaimed Jackpile-Paguate Uranium Mine.

The objectives of this report are to:

1. Determine if the soils and vegetation testing met the requirements in the Jackpile-Paguate Reclamation Project Record of Decision (ROD) (DOI₂, 1986) as defined in the Environmental Impact Statement (DOI₁, 1986)
2. Review the soil and vegetations chemical and radiological data collected and applied topsoil depths during reclamation for requirements established in the ROD.
3. Make recommendations on how to overcome any ROD deficiencies.

2.0 BACKGROUND

The area of the mine and surrounding landscape is a region of broad mesas and plateaus separated by deep canyon, dry washes, and broad alluvial valleys on the southeastern edge Colorado Plateau province. This is a semi-arid region underlain by flat lying interbedded rock strata of Upper Cretaceous shale (Mancos) and associated sandstones (Tres Hermanos and Jackpile). Soils are predominantly shallow sandy loam to sandy clay loam on the mesas and slopes, and alluvial fine-grained deep soils in the valleys (DOI₁, 1986). Approximately 3.1 million cubic yards of topsoil materials (mostly crushed Tres Hermanos Sandstone) were stockpiled on the mine site and were used as topsoil during revegetation. In addition, a borrow area for topsoil of 44 acres was also utilized as needed. The revegetation project involved the filling of three open pits using protore (sub-grade ore) stockpiles, substrate materials from mine waste rock dumps, and covering with topsoil stockpiles.

Reclamation and revegetation techniques were first tested by the Anaconda Mining Company (AMC) starting in 1976, and continued on 11 additional waste piles in 1977, 1979, and 1980-1981 (Weston, 1991). The techniques AMC tested included topsoiling procedures based on soils analysis, seed mixtures, fertilization, and straw mulching. The results of the soil surveys on mine reclaimed waste dumps, stockpiled soils, and various locations within the mine site showed that all of the soil samples can be considered suitable plant growth media (Weston 1991). Soils from a few areas may have problems with permeability or salt content if used in isolation.

There was no site activity from 1982 to 1989. Final reclamation of the entire mine site started in 1990, and was completed at the end of 1996. The work involving topsoiling started in 1991 on waste dumps, and was continued on slopes and in pit bottoms until 1995.

3.0 SOILS MONITORING AND ANALYSIS

Monitoring for soils was specified in Table 1-5 in the EIS as once prior to seeding. The proposed soils monitoring program is presented in Table 3-1. The ROD specified that the waste dumps with Jackpile Sandstone would be covered with 3 feet of overburden (generally Mancos Shale), and 18 inches of topsoil. Protore (Jackpile Sandstone, JPSS) used as backfill in pit areas would be covered with 3 feet of overburden, and 2 feet of Tres Hermanos Sandstone or alluvial material.

Overview of Soil Reports - Several documents present soil sampling results, and recommendations for use and need for monitoring before and after final reclamation. The Jacobs Environmental Monitoring Plan was designed to meet the specifics of the ROD and was, in fact, the approved plan that superseded the EIS table of recommendations. The Jacobs Environmental Monitoring Plan called for annual monitoring of salt in the pit bottoms for ten years, which would meet the requirements of the ROD; however, this monitoring was apparently not performed. The Soils and Vegetation Evaluation (Weston 1991) completed before reclamation started, indicates that no further soils testing should be required. The reports by Munk and Boden (Munk and Boden, 1996, 1997), which reported results of soils monitored after reclamation was complete, described soil profiles and characteristics in the pit bottoms, and provided discussion on potential for plant uptake from soils. There are no reports or records of soil being tested beyond the Munk and Boden reports of 1997.

There were three types of soils testing discussed in documents associated with the Jackpile Reclamation:

- 1) testing for suitability for topsoil that could support revegetation goals,
- 2) testing for salt buildup that could reach concentrations toxic to plants and
- 3) testing of heavy metals and radiological compounds.

**Table 3-1
Soils Testing Requirements Comparison**

	EIS Table 1-5	ROD	Jacobs Environmental Monitoring Plan	Actual
Sampling Points	One grid per 50 acres on each waste dump and pit bottom	Item 10: EIS Table 1-5 Unspecific	<u>For Salt Buildup</u> NP Pit: 2 east, 2 west SP Pit: 2 east, 2 west Jackpile: 4 locations Half the locations in each pit will be in areas where ponding occurs after large precipitation events and half on well-drained areas. Sample collected from 3 to 9 inches below surface. Sampling points marked with 3 foot steel posts.	1.) <u>For Topsoil Suitability</u> Landmark/Weston (1991) collected 38 samples from 26 locations in the pit areas. 2.) No Salinity Sampling 3.) <u>For Potential for Plant Uptake</u> Munk & Boden (1997) collected 12 samples

Frequency	Once Prior to Seeding	Annually	1.) Once 2.) Never 3.) Once
Parameters	U(natural), RA-226, Th-230, Se, Va, As, Cd, Mo, Pb, Zn	EC of saturated paste extract	1.) pH, EC, saturation %, Ca, Mg, Na, SAR, soil characteristics 2.) As, Cu, Mo, Pb, Se, Zn, Va, Pb-210, Po-210, Ra-226
Duration	Once Prior to Seeding	Begin after backfilling and continue for 10 years	1.) Once 2.) Not Done 3.) Once

3.1 Topsoil

The Jacobs Monitoring Report discusses soil testing to determine suitability for top dressing which was part of the reclamation operations and included in the construction specifications. It was not a part of the Long Term Post Closure Monitoring Program discussed in ROD Item 10. There are several reports which contain data on soils for suitability for top dressing.

a.) Landmark/Weston (1991)

In 1991, personnel from Weston collected and analyzed 38 soil samples from 26 locations in the South Paguate, North Paguate, and Jackpile areas. The soils sampled were analyzed for pH, EC, saturation percent, calcium, magnesium, sodium, sodium adsorption ratio, sand, silt, clay, and texture. These parameters were measured to determine the suitability of the soil to serve as top dressing over the Mancos Shale, and support growth of native species.

The results of the soil monitoring by Weston personnel (Landmark Reclamation/Weston, "Jackpile Reclamation Project, Pueblo of Laguna, New Mexico, Soils and Vegetation Evaluation for Final Reclamation", Final, April 1991.) showed moderate soil parameters within normal ranges. Soils were moderately alkaline with a pH range of 7.3 to 8.2, low conductivity of 0.35 to 3.77 (with one sample to 5.37), and low sodium adsorption ratio (SAR) ranging from 0.11 to 1.13 (three samples were higher to 5.07), and textures from loam to sandy clay loam. Concerns raised by this study were the potential for high sodium content and low permeability soils. However, most soils had low clay content allowing salts to be leached. Other concerns were for high permeability with low water holding capacity; however, topsoiling materials were mixed and placed over shale, which compensates for high permeability. There were some areas showing potential revegetation problems that could not be attributed to soil conditions alone. The conclusion of this soils study was that the topsoiling material tested could support successful revegetation, and no further soils testing was necessary.

b.) Munk and Boden (1996, 1997)

The report on interim reclamation by Munk and Boden (1996) presented a table of soil characteristics for the cover materials in the pit bottoms from 6-foot deep pits. The parameters recorded were material depths, color, texture, percent fragments, effervescence, and rooting depths.

There is information in the abbreviated soils descriptions in the reports by Munk and Boden (1996, 1997) on soil depths and characteristics in three pit bottoms. One purpose of the soil investigation was to evaluate the general characteristics. Depths of topdressing ranged from 18 to 60 inches with an average depth of 30 inches; depths of shale ranged from 7 to 36 inches with an average of 21 inches. Textures were medium and varied from sandy loam to silty clay. The pH measured in this study ranged from 7.7 to 8.2, and EC ranged from 0.93 to 11.2. Soluble calcium was typically high from sulfate solid phases. The dark Mancos Shale layer is medium to fine texture with clay contents up to 45%. This shale was a mixed substrate with pH ranges from 3.5 to 7.8, and also had a high level of soluble calcium. The acid forming potential of the shale is limited as indicated by Acid Base Account evaluation.

c.) Miscellaneous Field Data Sheets

Field data sheets measuring shale and topsoil cover of waste dumps during 1991 and 1993 showed topsoil depths averaging 18 to 20 inches, and shale cover from 12 to 14 inches. No information was available on pit bottoms from these data sheets.

Suitability of topsoil dressing material was adequately measured prior to the start of reclamation. The soils were found to be suitable for revegetation, and further testing should not be required. This soils evaluation met the requirements of the ROD for monitoring soils once prior to seeding. The parameters measured were different from that specified by the EIS; however, the parameters measured identified the soils as suitable for plant growth.

The results of the soils monitoring showed varying depths of topsoil and overburden cover on the waste dumps and pit bottoms. There were two periods of measuring soil cover depths; 1) during construction on waste piles, and 2) post reclamation in the pit bottoms. The cover depths were adequate to provide growth media for plant growth and revegetation. Topdressing materials averaged 30 inches and shale overburden 21 inches for a total cover depth of 51 inches (4.25 feet). The ROD specified 3 feet of overburden, and 2 feet of topsoil for a total of 5 feet. The difference of 0.75 feet can be attributed to settling and compaction after soils were placed.

Conclusion

Overall, soils used for revegetation on the mine site were suitable for plant growth, and presented no problems for vigorous and productive vegetation communities. The reports on soils evaluation showed that the soil parameters were within normal ranges for local and native soils. Appropriate topsoil source areas were found and appropriate depths were laid down.

3.2 Salt Buildup

The ROD required salinity monitoring in the pits. The Jacobs Monitoring Plan directed the soils in the pits be monitored for salt buildup since a survey of drainages blocked by waste dumps showed the build-up of salts to levels toxic to plants in areas adjacent to the blockage. There were no data found regarding monitoring for salt in soils. No salinity in soils was monitored.

Conclusion

The ROD requirement to monitor salt buildup for impact to vegetation has not been met. Although visual inspection during reclamation and post reclamation does not indicate the presence of salinity induced stress in revegetated areas, a one time sampling and analysis of soils in areas adjacent blockages is recommended to verify this conclusion.

3.3 Radiologicals and Heavy Metals in Soils

The EIS Table 1-5 presents radiological and heavy metal parameters to be tested in soils from the dumps and pit bottoms, to assess potential for plant uptake. There was a one-time sampling of soils for chemical and radiological analyses. In September/October 1996 (Munk and Boden, 1997) 12 locations in the pit bottoms were sampled for soil parameters and characteristics after reclamation was complete, primarily for determining plant uptake of heavy metals and radionuclides. They sampled the topdressing (Tres Hermanos Sandstone TD), Mancos Shale (MS), and Jackpile Sandstone uranium protore (JPSS) layers. The constituents measured included arsenic (As), copper (Cu), molybdenum (Mo), lead (Pb), selenium (Se), zinc (Zn), vanadium (V); and the radionuclides lead-210 (^{210}Pb), polonium-210 (^{210}Po), and radium-226 (^{226}Ra).

The Munk and Boden (1997) reports that samples were taken at 12 locations within the pits for some radiological and heavy metals compounds. The reported results of soils monitored after reclamation was complete, provided discussion on the potential for plant uptake from soils. Their analysis of the soil topdressing, shale cover material, and protore in the pit bottoms indicated that the heavy metals, arsenic, copper, lead, molybdenum, and zinc occurred at typical levels for natural soils. They concluded that additional measurements of arsenic, copper, lead, molybdenum, and zinc were not warranted in the pit bottoms. However, the heavy

metals, selenium and vanadium, and the radionuclides, radium-226, lead-210, and polonium-210, occurred at elevated levels in the Jackpile Sandstone protore. These metals and radionuclides have the potential for redistribution to the soil surface by vegetation, and should be monitored.

Conclusion

Because of the construction of barrier covers over the protore in the areas that had elevated metals and radionuclide concentrations, those areas should be of no concern. The ROD requirement for monitoring was met for soil testing.

4.0 Plant Uptake Monitoring and Analysis

The EIS recommended several reclamation and revegetation activities that were intended to reduced the potential for vegetation uptake of metals and radionuclides or prevent grazing. The activities included:

1. Moving stockpiled protore (Jackpile Sandstone) into the pits and covering with overburden (Mancos Shale) and topsoil (Tres Hermanos Sandstone) before seeding for revegetation.
2. Covering exposed surfaces of Jackpile Sandstone on waste dumps with overburden and topsoil.
3. Clearing and moving contaminated materials from facilities, roads, rail spur, and disturbed sites; and topsoiling all disturbed sites (old roads, etc.) before revegetation.
4. Stabilizing slopes of waste dumps and pit highwalls.
5. Fencing pit bottoms (to prevent access of domestic cattle and human entry).

There was no site activity from 1982 to 1989. Final reclamation of the entire mine site started in 1990, and was completed at the end of 1996. Monitoring for vegetation uptake started with soils investigation in 1996 and continued with vegetation monitoring until 2006.

Requirements of the ROD and EIS, concerning monitoring for heavy metals and radionuclides uptake, were specified in Table 1-5 in the EIS. Table 4-1 presents the proposed and actual monitoring for vegetation uptake.

Table 4-1
Comparison of Monitoring Requirements for Radionuclide and Heavy Metal Uptake Into Vegetation Comparison

	EIS Table 1-5	ROD	Jacobs Environmental Monitoring Plan	Actual
Sampling Points	Transects on selected reclaimed waste dumps and all pit bottoms	Item 12: EIS Table 1-5, minimum 10 years following reseeded	One location per dump with JSS on outer surface	Pit Bottoms
Frequency	Annually		Annually	2001, 2003, 2005, 2006
Parameters	U(natural), RA-226, Po-210, Th-230, Se, V, As, Cu, Cd, Mo, Pb, Zn		Edible Fraction for Ra-226, Po-210, Pb-210, Se, Va, As, Mo, Pb, Cu, Zn	As, Cu, Pb, Mo, Se, V, Zn, Pb-210, Po-210, Ra-226
Duration	A minimum of 10 years following reclamation		Commence one year after reseeded for a minimum of 10 years following reclamation. Increase locations if the trends indicate that toxic levels are being approached.	

Overview of Uptake Reports Two documents in addition to the ROD and EIS dealt with the proposed vegetation uptake monitoring program after final reclamation.

a.) Jacobs, 1989

The Jacobs Environmental Monitoring Report reports that early data sets showed that “*vegetation on the disturbed areas is not accumulating heavy metals or radionuclides in concentrations that are toxic to livestock*”, but that it would be prudent to monitor to see if uptake changed with time. The monitoring plan proposed by Jacobs Engineering (Jacobs 1989) suggested annual monitoring begin one year after seeding and continue for 10 years. Thorium-230 was not included in the monitoring plan due to a low uptake factor, and Uranium (total) was also not included because of low plant uptake and a low conversion factor for the ingestion pathway. Instead, Polonium-210 was considered to have a greater potential human exposure pathway through ingestion, and was included in the monitoring that was implemented.

b.) Miscellaneous Data Sets

There were four years (2001, 2003, 2005, and 2006) in which vegetation was clipped and analyzed for heavy metals and radionuclides. The following metal and radionuclides were analyzed during these time periods:

1. June 2001, May 2003 and June 2005: heavy metals - As, Cu, Mo, Pb, Se, V, and Zn; radionuclides - ^{226}Ra , ^{210}Po , and ^{210}Pb .
2. September 2006: heavy metals - As, Cu, Mo, Pb, Se, V, and Zn; and radionuclides were analyzed.

The results of the vegetation uptake monitoring are presented in Table 4-2. The results presented are the range of values, number of non-detects or negative values, and the average value for each time period. The following summarizes the values for each metal and radionuclide.

The following presents a discussion of these data sets.

METALS

Arsenic: The average concentrations were low at 0.2 to 0.4 mg/Kg, with many non-detects. One maximum concentration at 5.0 mg/Kg was recorded, but no discernable trend was observed during the 5-year monitoring period.

Copper: This metal was detected in all vegetation samples at low average concentrations of 2.4 to 2.9 mg/Kg. There was one value of 7.6 mg/Kg, but there was no increase or trends noted during the sampling periods.

Lead: The average concentrations were low at 0.1 to 0.4 mg/Kg, with many non-detects. There was one value at 4.0 mg/Kg, but no trends were noted.

Molybdenum: The average concentrations were low at 0.2 to 0.5 mg/Kg, with many non-detects. There was one value at 3.7 mg/Kg, but no trends were noted.

Selenium: The concentrations varied from 0 to a maximum value of 42.9 mg/Kg. The concentrations measured in 2006 had increased in average value in the 2006 samples to 6.4 mg/Kg due to uptake by a perennial shrub (four-wing saltbush).

Vanadium: The concentrations were low averaging 0.6 to 1.5 mg/Kg with many non-detects.

Zinc: The concentrations were consistent in all plants sampled varying from 3 to 47 mg/Kg. Average values were 14 to 20 mg/Kg, with no trends in the years sampled.

Measured uptake concentrations of metals into vegetation were either below, or within, normal ranges for all heavy metals analyzed. As discussed by Munk and Boden (1997), the potential for uptake by most plants is minimal given the soil properties in the pit bottoms. This was confirmed by the four growing seasons (2001 to 2006) of vegetation sampled and analyzed for heavy metals (see Table 5-1, and discussion of concentrations in plant species sampled). There was some concern by Munk and Boden (1997) that selenium and vanadium may accumulate on the surface and be translocated from the Jackpile Sandstone backfilled and covered in the pit bottoms. However, there was no increasing trend of these two metals measured in the vegetation eleven years after revegetation was complete.

The concentration in one shrub (four-wing saltbush) analyzed for selenium was within a normal high range, and may indicate that this shrub species is a secondary accumulator.

This species is a member of the goosefoot family, and is not generally grazed by domestic livestock when other more palatable grass species are available.

Domestic livestock can graze the grass/shrub vegetation in the pit bottoms without toxic effects from heavy metals. Selenium was the only metal found to have the potential for sub-acute toxicity in one sample in one shrub species that is generally not browsed by livestock. It is recommended that heavy metals monitoring should not be required in the future based on the sample results to date.

RADIONUCLIDES

Lead-210: The concentrations measured in vegetation were consistently low at less than 1 pCi/g (range 0 to 1.1) with some non-detects, and averaging 0.07 to 0.50 pCi/g. There was no increasing or decreasing trend in uptakes measured

Polonium-210: The concentrations measured in vegetation were also consistently low at less than 0.4 pCi/g (range 0 to 1.16) with some non-detects, and averaging 0.05 to 0.28 pCi/g. There was a slight increase in uptakes measured in 2006 (1.16 pCi/g) due to values in perennial shrubs (four-wing saltbush), and one grass sample.

Radium-226: The concentrations measured in vegetation were generally low at less than 1 pCi/g (range 0.002 to 2.1) with some non-detects, and averaging 0.17 to 0.72 pCi/g. There was no increasing or decreasing trend in uptakes measured

The concentration levels of radionuclides in the plant samples analyzed were uniformly low with no increasing trends in levels over the four periods vegetation was sampled. The concentration levels are well below values that are considered toxic to domestic livestock or wildlife; therefore, sampling of radionuclides should not be required in the future.

**Table 4-2
Summary of Results of the Heavy Metal and Radionuclide Vegetation Uptake
Monitoring for the Jackpile Reclamation Project.**

Results are in mg/Kg (ppm) for metals, and pCi/g (picocuries per gram) for radionuclides.

*ND – non-detects or minus values

Year	2001 – 15 Samples			2003 – 10 Samples			2005 – 39 Samples			2006 – 16 Samples		
Metals	Range	ND*	Avg	Range	ND	Avg	Range	ND	Avg	Range	ND	Avg
As	0-0.8	13	0.2	-	10	-	0-5.0	10	0.8	0-3.3	12	0.4
Cu	1.1-4.0	0	2.5	1.3-4.7	0	2.4	1.4-3.8	0	2.5	1.9-7.6	0	2.9
Pb	0-1.3	13	0.1	0-1.8	8	0.02	0-4.0	25	0.4	0-2.2	12	0.4
Mo	0-2.1	12	0.2	0-3.7	9	0.4	0-3.3	6	0.4	0-3.1	8	0.5
Se	0.94	9	1.5	0-5.3	3	0.9	0-5.3	9	1.4	0.5-42.9	0	6.4
V	0-3.7	9	0.6	0-4.8	7	0.6	0-8.1	28	0.7	0-19.1	13	1.5
Zn	9-47	0	20	8-29	0	15	3-34	0	18	8-25	0	14
Radio-nuclides												
²¹⁰ Pb	0.1-1.9	0	0.44	0-1.12	1	0.50	0-0.3	14	0.07	0-0.87	4	0.28
²¹⁰ Po	0-0.5	5	0.17	.03-.34	0	0.12	0-0.2	2	0.05	.02-1.16	0	0.28
²²⁶ Ra	0-0.5	5	0.17	0.2-0.5	0	0.38	0-2.1	2	0.72	.002-.51	1	0.19